Cairo Air Improvement Project

Lead Pollution Abatement Component

Support for Selected Activities under the Lead Smelter Action Plan: Industrial Relocation in Abu Zaabal

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Executive Summary

Executive Summary

• Objective of the Study

The objective of this report is to:

- assess the impacts resulting from the relocation of foundries to a site specified in Abu Zaabal
- provide an urban planning for the estate
- set the restrictions and rules that guarantee the maintenance of environmental quality in the area and avoid deterioration of the environment
- report to EEAA on the EIA of the industrial estate in Abu Zaabal

• Outcome

The balance between a high density industrial development and the needs for environmental protection is achieved through an integration of planning, technological and managerial approaches. The impacts on the environment and neighboring receptors are minimized and is shown to be within acceptable limits. The industrial site planning of Abu Zaabal industrial site was approved by the Governorate Popular Council on January 29th, 2000. A Governorate decree has been issued to declare the Abu Zaabal site an industrial site. The decree has been sent for the Prime Minister for ratification.

• Nature of the Report

The environmental impact assessment for the relocation area in Abu Zaabal included in the report is submitted to EEAA based on an agreement between CAIP, EEAA and the Governorate that:

- The project promoter (the Governorate) and the industrial operators should accept their respective responsibilities specified in this draft report.

- Responsibilities of industrial operators should be clearly stated in the contractual agreements with the Governorate for plot allocation.

- A public scoping session, which timing will be decided by EEAA and the Governorate, should be held. In this session, the project will be presented to the public to be assured that each party would assume its responsibilities and is committed to the indicated criteria in the report to maintain the environmental quality of the area and avoid negative impacts.

- Each foundry will be required to submit a simplified EIA based on the main criteria or principles indicated in the study. The approval of this EIA is a condition for implementation of individual projects.

- ## Need For Relocation

Shoubra El Kheima district is one of the most polluted residential areas in Greater Cairo. It accommodates a large number of polluting industries within its residential and agricultural areas. The area suffers from poor environmental quality and its residents suffer from adverse health effects and contamination of agricultural vegetation. Shoubra El Kheima lies north of Cairo city and thus the wind carries all the industrial air pollution to the residents of city Cairo.

The Governorate of Qalubiya had decided to transfer most of the foundries from the area to a new location in Abu Zaabal district 30 km north of Cairo. The relocation would decrease the pollution load and improve environmental conditions in Shoubra El Kheima. However, relocating these industries in Abu Zaabal might have a number of adverse environmental and health effects that should be accounted for.

- ## Abu Zaabal Baseline Information

Chapter two gives a description of the baseline information for the physical, biological and social environment of the site and its surrounding area. It also overviews the relevant legislations and regulatory considerations.

- The proposed site was found to lie in a limited space of barren land surrounded by housing communities, army barracks and agricultural areas, which is considered as a constraint in terms of site development and facility distribution.
- The site has smooth topography that does not constrain site development.
- The climate is typical of the Cairo area arid conditions where wind direction varies across the year, with prevalence with a northern component.
- Generally, the nature of the rocks in this area is basaltic rock.
- Geo-technical investigations showed that the site is suitable for construction, does not place unnecessary burdens on the site development and does not impose special distribution of land uses.
- CAIP analyses have shown high pollution loads at the dumpsite area, which should be developed before construction begins.
- The designated area is part of the Belbeis Khanka desert and is not characterized by the presence of rare species of plants or threatened animals. The surrounding agricultural land, which starts 2km away from the site, includes a variety of cultivated crops, livestock and poultry.
- Regarding the social setting of the area, a preliminary survey had concluded that the residents of the existing community have negative attitudes of the relocation issue. The main reason behind this disapproval is the current pollution and poor living conditions that they are forced to endure.

- ## Production Technologies

Chapter 3 presents a description of the different processes undertaken in the foundries. For each process, material, water and energy consumption is given per ton of products. A description for different types of melting furnace, with a list of advantages and disadvantages, is also included.

Wastes and emissions from each foundry are studied to estimate the amount of wastes per unit production. Generated solid wastes include slag, dust and sand. Huge quantities of waste sand are usually generated, taking large spaces for storage and are liable to dispersion by means of wind causing nuisance. Slag generated from the foundries is not considered hazardous according to EPA and its amount depends on the type of furnace used in melting. The gaseous emissions emitted from the melting furnace, ladle preheating and shakeout units are also included together with a brief description for the most common control equipment such as the wet scrubber and the bag filter.

It was clear from the data that induction furnaces emit the least amount of gaseous emissions. Using induction furnaces especially for large foundries would provide both environmental and technological advantages since it would decrease the pollution load and improve the production quality. Using natural gas as a fuel would substantially reduce gaseous emissions especially sulfur dioxide since natural gas is of zero sulfur content. It is thus recommended to provide the industrial site with natural gas since it is of zero sulfur content.

An assessment for a sample of foundries located in Shoubra El Kheima was performed. The assessment revealed that most foundries use traditional production technologies and most operations are manual due to the availability of cheap labor. The high level of pollution is attributed to using low quality scrap, low quality fuel, non-foundry sand as well as lack of air cleaning, ventilation systems and efficient control equipment. A small number of the Shoubra's foundries were found to use induction furnaces. It was concluded that Shoubra El Kheima foundries could not be relocated as they are. Certain technological changes and control measures should be performed to upgrade the foundries and reduce the pollution levels they generate.

- ## Impacts During Construction Phase and Proposed Mitigation Measures

  - **Negative Impact on Water Quality – Can Be Mitigated**
    Irreversible long-term regional direct negative impact due to possible seepage of water into two depressions, in the northern part of the site, could cause contamination of the groundwater. Mitigation measures include lining the depressions with a layer of impervious material.

  - **Negative Impact on Air Quality – Can be Mitigated**

Reversible short-term local direct negative impact due to the emission of dust and fumes during construction activities. Mitigation measures include setting proper material storage areas to prevent dust dispersion.

- **Negative Noise Impacts**
  Reversible short-term local direct negative impact as a result of noise and vibrations resulting from equipment and vehicles. Mitigation measures include using proper construction equipment and prohibiting working at night.

- **No Impact on Agricultural Land**
  There will be no impact on field crops because the nearest agricultural land is at a distance of 2 km north of the site.

- **Impact on Flora and Fauna – No Mitigation Measures Proposed**
  Irreversible long-term local direct negative impact on site and reversible short-term local indirect negative impact off site due to extermination of plants and most small animals on site and the migration of some animals to neighboring areas.

- **Positive Employment Opportunities**
  Reversible short-term local and regional direct positive impact as a result of the increase in demand of temporary labor during construction phase.

- **Negative Impact on Health and Safety – Can Be Mitigated**
  Reversible short-term local direct negative impact due to migration of rodents and rats to the neighboring residential areas as well as due to potential accidents. Mitigation measures include exterminating rodents and rats before starting any earthworks.

- **Negative Social Impacts -Can Be Mitigated**
  Reversible short-term local direct negative impact due to the presence of construction crews in the site. Mitigation measures include locating shelters of the construction crews west of the railway to be away from the residential areas and providing them with proper services,.

• Impacts During Operation Phase

- **Negative Impact on Water Quality – Can Be Mitigated**
  1. No impact on surface water
  2. No impact on groundwater
  3. Negative impact on public sewer system[1] if wastewater is discharged directly without treatment. It is proposed to implement a central wastewater treatment plant.

[1] Although there is no public sewer system in the area, reference is made to the sewer system that will be implemented by the Governorate

- **Negative Impact on Land Quality – Can Be Mitigated**
  Irreversible long-term local direct negative impact due to the huge amount of raw materials and solid waste. Mitigation measures include implementing a central transfer station for solid wastes and central stores for raw materials. Other measures are proposed for waste minimization.

- **Negative Noise Impacts – Can Be Mitigated**
  Irreversible long- to short-term local direct negative impact due to exposure of noise from foundries operations. Mitigation measures include prohibiting night shifts and completely separating the residential area and industrial area by the railway and a buffer of trees along the railways.

- **Negative Impacts on Occupational Health– Can Be Mitigated**
  Reversible/irreversible long-term local direct negative impact due the exposure of workers to noise, fugitive dust emissions and heat stress. Mitigation measures include installation of adequate ventilation systems and providing workers with protective equipment.

- **Positive Impact on Employment**
  Irreversible long-term local and regional direct and indirect positive impact due to the presence of services that may create employment such as the proposed solid waste transfer station.

• Impacts of Air Quality During Operation Phase

The potential effects of the urban planning of the area on air quality were assessed since it was found that air quality is the only parameter that is sensitive to the distribution scheme of the industries and utilities. The main critical pollutants that may affect the air quality are sulfur dioxide, particulate matter, carbon monoxide, lead and copper. Modelling was used as a scientific simulation tool to predict the ambient quality for each proposed alternative in order to reach an optimum layout for the different industries insuring the best possible ambient quality.

It was clear from the modelling results that sulfur dioxide appears to be the limiting case since in all generated alternatives, which differ only in the relative distribution of foundries, its concentrations are still exceeding the allowable limit in southern and northern wind direction. This means that positional variations alone will not achieve the best air quality. Other technological variations would be needed to minimize air pollution. A final scheme was formulated including redistribution of foundries and confining foundries of areas greater than 1000 m^2 to using induction furnaces whose emissions is negligible with respect to other furnaces.

In case natural gas is available in the industrial estate, close consultation with foundries operators would be necessary to investigate the possibility of switching to natural gas (zero sulfur content) instead of using coke and liquid fuel. Large foundries might consider using natural gas instead of induction furnaces, yet the decision depends on several issues such as the quality of castings, that is higher in case of induction furnaces.

The selected scheme yielded satisfactory results for all pollutants including sulfur dioxide and the impacts of air quality on public health and biological life were identified. It was shown that:

- **No Impact on Public Health**
  There will be no impact on public health since the concentrations of pollutants reaching the residential areas in the east are way below the corresponding allowable limits representing no hazard on public health.

- **No Impact on Agricultural Land**
  There will be no impact on the agricultural land located 2 km to the north since pollution concentration do not extend to reach this area.

- **No Impact on Fauna or Flora**
  Wild animals and plants in the area were found to tolerate pollution loads. Moreover, some wild plants are capable of absorbing lead from the air.

- **No Impact on Domestic Animals**
  The farms, located 4 km away north and north-east of the industrial site, will not be affected by air quality in the area because they very far from pollution sources.

- Urban Planning

Planning regulations and principles, related to population, employment and building densities as well as zoning and land use, were applied to the design of the industrial estate in Abu Zaabal. A number of iterations were performed to feed in increasing environmental constraints. The final plan includes totally separate zones for industries and residences integrating the latters in the existing community of Abu Zaabal and provides a model for small-scale industrial estates in Egypt. It accommodates more than the current demand for industrial plots as well as services for both residential and industrial zones. The large labor force of the relocated foundries is expected not to be all accommodated in the residential zone. However, this can only be checked through a detailed social study focussing on the real willingness of workers to be relocated.

The direct request to provide access from two streets to each industrial plot was accommodated which has resulted in a less denser development and would help industrial operators better plan their work flow. However, it should be stated that urban planning law restricts access of industrial plots to one street (except for corner plots). The objective is to limit the possibility of subdivision of plots, which would have to be addressed differently in this case. The plan is detailed to the level of execution drawings in appendix (L).

- Responsibilities of Concerned Parties

Chapter 8 gives the responsibilities of all concerned parties to maintain the environmental quality of the area. The governorate has several responsibilities concerning inputs to implementation, controlling impacts during construction, operation and management of the industrial estate as well as protection of surrounding land:

The operators are responsible for complying with work environment and emissions standards specified in law 4/94 except for SO_2 emissions where the limits set for the industrial estate (200 mg/m^3) are lower than those specified in the law and will submit individual EIAs. Moreover, they will abide by the following rules and restrictions included in the contractual agreement to operate on the Abu Zaabal industrial estate.

The estate management will be responsible for the management of contracts, excess land allocation and the environmental management unit is responsible for the inspection of industries and central services

Chapter 1
Introduction

Chapter 1 is an introduction for the document discussing the need for relocation and gives an overview of the document.

- Shoubra is one of the most polluted districts in Egypt. Transferring foundries from Shoubra and relocating them in Abu Zaabal will minimize pollution in Shoubra yet raises worries of potential pollution and adverse effects in Abu Zaabal.

- The objective of the document is to assess environmental impacts of the project, provide urban planning of the area and set restrictions to maintain environmental quality.

- The document is submitted to EEAA based on the understanding that all parties would assume their respective responsibilities.

1.1 Background

The Government of Egypt, through the Egyptian Environmental Affairs Agency (EEAA) has developed a Lead Smelters Action Plan (LSAP) as a part of a comprehensive plan for lead abatement in Cairo, "Lead Exposure Abatement Plan". Its purpose is the reduction of airborne and workplace emissions from lead smelters and the relocation of such smelters from areas of concentrated population to industrial zones.

The Cairo Air Improvement Project (CAIP) has developed a Lead Pollution Abatement (LPA) program to support the implementation of the LSAP. This is accomplished through the following specific objectives:

- Upgrade the operation processes of large lead smelters
- Provide technical assistance to cooperative, licensed small and medium sized lead smelters
- Establish and enforce a comprehensive, countrywide long-term solution to the lead pollution problem.

Decreasing emissions, without relocating the smelters, is one option. However, this solution is not viable due to the following facts:

- Heavy metals are not degradable, but accumulate in the environment. Decreasing the quantity of heavy metals would not necessarily keep them from accumulating to critical health levels, especially lead. It would just increase the time span over which it would accumulate.

- The affected communities and non-government organizations (NGOs) are going to continue to pressure the government and industry despite on site improvements.

- Polluting industries will eventually have to be relocated to areas outside the ring road according to the Master Plan of Greater Cairo.

- Most owners of private smelters have accepted the inevitability of relocation.

The long-term solution, therefore, lies in a two-pronged policy, which includes:

1. Relocating the plants outside highly populated areas (such as desert areas outside Cairo).
2. Using advanced production technology and applying advanced pollution abatement techniques, in addition to continuous monitoring and control.

Shoubra El Kheima district is one of the most polluted residential areas in Greater Cairo. Health hazards associated with foundries and smelters especially lead smelters in crowded areas are too dangerous to be tolerated. Moreover, Shoubra El Kheima lies to the north of Cairo city and thus the wind carries all the industrial air pollution to the residents of Cairo. On the other hand, southern and eastern wind may carry urban pollutants from Cairo to the area of Shoubra El Kheima. Furthermore, the location of the area makes it one of the principal sources of vegetables for Cairo residents. Thus, the danger lies in the accumulation of toxic heavy metals such as lead in the edible vegetables where they interfere with the human food chain.

The Qalubiya governorate is planning to transfer some of these industries outside the residential areas. An agreement, between the Governor of Qalubiya governor and industrial operators, was reached to relocate the smelters and metal foundries to an industrial estate in Abu Zaabal district.

Relocation of polluting industries away from the residential areas of Shoubra El Kheima may help improve the air quality of Northern Cairo and reduce health risks in this area. However, relocating these industries in the assigned site in Abu Zaabal has a number of potential adverse environmental and health effects that should be taken into consideration.

One of the basic milestones planned in the LPA agenda is the preparation of an environmental impact assessment (EIA) for the new Abu Zaabal industrial site allocated by the Governorate of Qalubiya for relocation of the foundries and smelters of Shoubra El Kheima.

1.2 Current Status of Shoubra El Kheima

1.2.1 Air Quality

According to the CAIP Air Quality Monitoring Component (AQMC) and particulate matter (PM) and lead monitoring results, obtained from 36 sites in Greater Cairo during October 1998 to July 1999, the highest PM10, PM2.5 and lead concentrations during this period were observed in the industrial areas of Shoubra El Kheima. Mean inhalable particulate matter (PM10) levels were found to be 313 $\mu g/m^3$ exceeding the allowable limit of Law 4/1994 (70 $\mu g/m^3$). As for the lead levels, 26 $\mu g/m^3$ were recorded which also exceeds Law 4 annual average of 1.0 $\mu g/m^3$. Measurements were conducted downwind of the secondary lead smelters and include measurements of fugitive emissions from these facilities.

Moreover, the Environmental Information and Monitoring Program (EIMP) of the EEAA has a national air pollution monitoring program consisting of a total of 40 measurement sites. The highest number of hours with SO_2 concentrations above 350 $\mu g/m^3$ (law 4 limit for an exposure time of 1hour) was recorded at Shoubra due to the industrial emissions.

1.2.2 Damage to Plants

In the industrial area of Shoubra El Kheima, high rates of heavy metal deposition were recorded over different sectors of the region. This has resulted in the contamination of the cultivated soil with several heavy metals such as lead, cadmium and zinc and increased toxic metal concentrations in the edible portions of the plants.

Symptoms of plant damage appeared in the form of chlorosis and necroisis and inhibition of photosynthesis. The decrease in chlorophyll reached more than 60% in plants cultivated in the industrial region. Plant growth and dry weights were reduced by more than 50%. The reduction in chlorophyll and growth parameters was correlated with the concentrations of air pollutants measured in the atmosphere of the industrial region. (Esmat Ali, 1993)) These effects of pollution injuries can be related mainly to the concentration of NO_X, SO_2 and ozone.

1.3 Proposed Site Location and Plan

In April 1998, the Qalubiya governor has taken the decision to relocate the foundries in an area of 142.23 feddans (59.7368 ha). The industrial site, allocated for foundry relocation, is located in Qalubiya governorate about 30 km North of Cairo. It is accessed primarily via the "agricultural" road connecting Cairo and Ismailia cities.

The site will be divided into zones or areas for the:

- Smelters and metal foundries (90 smelters are to be transferred: cast iron, copper and aluminum and lead).
- Residential areas and services (housing, mosque, fire stations,etc.)
- Green areas
- Roads

Tables (1.1, 1.2, 1.3) give the number of the foundries to be relocated, their areas and their production capacity**.**

Table (1.1) Relocated Cast Iron Foundries

Foundry Area (m^2)	Number	Total Area (m^2)	Foundry Production Capacity (ton/year)	Total Production Capacity (ton/year)
15000	1	15000	30000	30000
10000	2	20000	20000	40000
5000	12	60000	7500	90000
2000	20	40000	3000	60000
1000	15	15000	1000	15000
500	10	5000	500	5000
Total	**60**	**155000**		**240000**

Total area in feddan = 36.9
Source: Qalubiya Governorate

Table (1.2) Relocated Copper and Aluminum Foundries

Smelter Area (m^2)	Number	Total Area (m^2)	Foundry Production capacity (ton/year)	Total Production capacity (ton/year)
1000	5	5000	1000	5000
500	10	5000	500	5000
200	12	2400	200	2400
Total	**27**	**12400**		**12400**

Total area in feddan = 2.95
Source: Qalubiya Governorate

Table (1.3) Relocated Secondary Lead Smelters

Smelter Area (m^2)	Number	Total Area (m^2)	Foundry Production capacity (ton/year)	Total Production capacity (ton/year)
15000	1	15000	30000	30000
4000	1	4000	6000	6000
5000	1	1500	1500	1500
Total	**3**	**20500**		**37500**

Total area in feddan = 4.88
Source: Qalubiya Governorate

Total production capacity of all foundries and smelters = 289900 ton/year
Expected total labor capacity = 2000 workers

1.4 Scope of the Report

A plan for the industrial estate and an environmental impact assessment for the scheme are prepared to ensure protection and conservation of the environment and natural resources. Baseline information regarding natural and man-made context was collected and analyzed, positive and negative impacts were predicted, mitigation measures for both construction and operation phases were identified together with monitoring plan. Moreover, the study contains the steps and procedures necessary to have an environmentally sound industry and relocation site.

It should be noted that:

- The procedures of declaring the site as an industrial area have already been undertaken by the Governorate. Therefore, the study does not consider alternative sites for foundry relocation nor alternative uses of the site. It is limited to the assessment of environmental impacts of the planned relocation.

- A detailed social study was not within the scope of this study. It provides, however, a guidance to a possible future social study.

1.5 Organization of the Document

The study consists of eight chapters.

The current chapter is an introduction discussing the background of the project and an overview of the environmental status of Shoubra El Kheima.

Chapter 2 is an overview of the current environmental status of the proposed relocation site of Abu Zaabal including a description of its physical, chemical, biological and sociocultural environment.

Chapter 3 contains a description of the present old technologies adopted in Shoubra ElKheima and the proposed technologies for the relocated foundries as well as the emissions of each based on the production rate.

Chapter 4 gives the principles, process, and product of developing Abu Zaabal industrial site. The chapter addresses relevant sector analysis, programs and plans, in preparation for an integrated physical, social and economical development of the site.

Chapter 5 is the impact assessment of both the construction and operation phases including potential positive and negative impacts on the surrounding environment and the proposed mitigation measures to minimize these impacts.

Chapter 6 assesses air pollution using the Gaussian Plume Model to predict the impact of foundries operation on ambient air quality in the area based on the alternative urban plans. The impacts of air quality on human health and biological life are also included.

Chapter 7 is a detailed urban plan proposed for the layout of the site identifying the plot distribution for different land uses together with a summary of the planning concept and elements and recommended building requirements for industrial sites. Infrastructure requirements for the project are also described.

Chapter 8 gives the conclusions and recommendations derived for the study regarding the proposed relocation plan.

Chapter 2
Baseline Information

This chapter contains baseline information about the physical, biological and social environment of the site and its surrounding area. It also overviews the relevant legislations and regulatory considerations.

The following was concluded:

Constraints for Site Development :

- The site is a limited area of barren land edged by environmentally sensitive areas such as agricultural land and residential areas.
- The dumpsite is the main pollution source in the area and should be developed before construction begins.
- Abu Zaabal community expressed social resistance to the project due to the current deteriorated conditions they are forced to endure.

Site Advantages:

- The nature of rocks in the area is basaltic rocks which protects the groundwater
- The site is suitable for construction and its selection does not place any burdens on the site development nor impose special distribution of land uses in the site
- The topography of the site does not constrain the site development.
- The area does not contain any rare species of plants or threatened animals.

2.1 Site Description

The site under investigation is edged by housing communities to the north and east, an army barracks to the west, and quarry depressions to the north. It is accessed by a main road, edging the eastern edge of the site, across of which are found Massaken Abu Zaabal (housing), Abu Zaabal training center and a school. To the north, the Sekka Al-Hadid club and El-Arab area edge the site creating an internal alcove. Beyond the northwestern edge, agricultural land is predominant. Within the site, railway tracks bisect the site to eastern and western sectors. The site edge is irregular and defined by the adjoining functions to the north, west, and south. On the eastern site, the El-Madaress road edges it.

The site is thus a limited area of barren land surrounded with environmentally sensitive areas such as agricultural land and residential areas. This acts as a constraint to the intended development in terms of facility distribution within the site and its reflection on the resulting impacts. Moreover, neighboring quarries and dumpsite are potential sources of air pollution.

Appendix A contains a map of Abu Zaabal area and a cadastral map of the site.

2.2 Physical Environment

2.2.1 Topographic Characteristics

The site has a smooth topography. It slopes from the highest point in the middle of its southern east part that is 25 m above sea level, to 23 m in the north, to 24 m above sea level in the south and to 23 m above sea level in the west. Two depressions in the northern part of the site indicate abandoned quarries, in addition to an active quarry in the central west.

A deep hole is located in the western south part of the land. At the bottom of this hole, a very salty swamp is formed due to the accumulation of water that penetrates the layers through the fissures and joints of the basalt that exists in the area. It is currently used as a dumpsite.

Chemonics Egypt has assigned a surveying office to conduct a topographical survey. *Its findings are shown in a map in Appendix B.*

The topography of the site does not constrain the site development. The site will be leveled at the level of the railway track and the cuts of the higher mounds will be used to fill the existing depressions.

2.2.2 Climatic Characteristics

Cairo area is subject to arid climatic conditions. Temperature variations in this region are in the range of 8.9 to 29.2 °C in winter and from 14.5 to 34.7°C in summer. The average humidity of air may reach up to 60%. The total annual rainfall is 25 mm. The amount of rainfall increases northward to 40 mm / year near Banha at the north.

Evaporation amounts to 2000 mm/year, reaching its maximum in summer (8 mm/day). In more than 20% of each month of the year, wind is calm or blows in the least speed category (from 1 to 3 knots). Although the dominant winds vary in direction across the year, within the least speed category, there is a clear prevalence of wind with a northern component. This disturbing wind velocity and its prevailing direction are taken into account for the land use distribution.(see chapters 5,6,7)

Tables (2.1,2.2) show the monthly averages of the meteorological conditions based on “Cairo Airport” monitoring station and a summary of data sheets for the wind velocities.

Table (2.1) Monthly Rates for Meteorological Parameters in Cairo*

Parameter	Months											
	Jan.	**Feb.**	**March**	**April**	**May**	**June**	**July**	**August**	**Sept.**	**Oct.**	**Nov.**	**Dec.**
Maximum Temperature,°C	18.8	20.5	23.6	28.3	32	33.9	34.7	34.2	32.6	29.2	24.7	20.2
Minimum Temperature, °C	8.9	9.6	11.6	14.5	17.6	19.9	21.9	22.0	20.3	17.3	14.0	10.3
Relative Humidity, %	59	55	52	46	45	48	56	59	59	58	61	60
Rainfall (mm/month)	5.2	3.9	3.8	1.2	0.4	0.1	0	0	0	0.7	3.9	6.3

Source: General Organization for Meteorology, Climate Department, 1999

* This information covers an area of 50 km diameter.

Table (2.2) Distribution of Wind Direction in Different Months
(wind speed 01-03 Knot)

Direc.	Jan.		Feb.		Mar.		Apr.		May		Jun.		Jul.		Aug.		Sep.		Oct.		Nov.		Dec.	
VARIABL	0.5	2.2	0.6	3.2	0.5	3.4	0.4	3.1	0.3	2.6	0.2	1.4	0.1	0.6	0.1	0.5	0.2	1.1	0.4	2.1	0.5	2.0	0.6	2.5
345-014	2.6	11.5	2.3	12.3	2	13.7	2	15.7	2.2	19.0	3.1	22.5	4.6	26.4	5.4	27.6	5.1	27.9	4.4	22.6	3.5	14.0	2.9	12.0
015-044	1.9	8.4	1.7	9.1	2.1	14.4	2	15.7	1.7	14.7	1.8	13.0	1.8	10.3	2.3	11.7	3.5	19.1	3.6	18.5	2.9	11.6	2	8.3
045-074	1.9	8.4	1.7	9.1	1.6	11.0	1.3	10.2	1.4	12.1	1.1	8.0	0.9	5.2	1.2	6.1	1.9	10.4	2.7	13.8	2.9	11.6	1.9	7.9
075-104	1.9	8.4	1.5	8.0	1	6.8	0.7	5.5	0.7	6.0	0.4	2.9	0.3	1.7	0.4	2.0	0.6	3.3	1.5	7.7	1.9	7.6	2.1	8.7
105-134	1.6	7.1	1.1	5.9	0.7	4.8	0.3	2.4	0.3	2.6	0.2	1.4	0.1	0.6	0.2	1.0	0.2	1.1	0.7	3.6	1.6	6.4	2.1	8.7
135-164	1.5	6.6	1	5.3	0.5	3.4	0.3	2.4	0.2	1.7	0.1	0.7	0.1	0.6	0	0.0	0.1	0.5	0.5	2.6	1.3	5.2	1.8	7.5
165-194	1.5	6.6	1	5.3	0.5	3.4	0.3	2.4	0.1	0.9	0.1	0.7	0	0.0	0	0.0	0	0.0	0.3	1.5	1.1	4.4	1.8	7.5
195-224	1.7	7.5	0.9	4.8	0.6	4.1	0.4	3.1	0.1	0.9	0.1	0.7	0	0.0	0.1	0.5	0.1	0.5	0.3	1.5	1.1	4.4	1.5	6.2
225-254	1.3	5.8	1	5.3	0.6	4.1	0.6	4.7	0.3	2.6	0.3	2.2	0.3	1.7	0.2	1.0	0.2	1.1	0.4	2.1	1.2	4.8	1.2	5.0
255-284	1.7	7.5	1.5	8.0	1.2	8.2	1.2	9.4	1	8.6	1.4	10.1	1.7	9.8	1.5	7.7	0.9	4.9	0.9	4.6	2	8.0	1.7	7.1
285-314	2.1	9.3	2.1	11.2	1.5	10.3	1.5	11.8	1.3	11.2	2.3	16.7	3.4	19.5	3.5	17.9	2.1	11.5	1.6	8.2	2.3	9.2	2.3	9.5
315-344	2.4	10.6	2.3	12.3	1.8	12.3	1.7	11.3	2	17.2	2.7	19.6	4.1	23.6	4.7	24.0	3.4	18.6	2.2	11.3	2.7	10.8	2.2	9.1
All Direc.	22.6	100	18.7	100	14.6	100	12.7	97.95	11.6	100	13.8	100	17.4	100	19.6	100	18.3	100	19.5	100	25	100	24.1	100
Calm	6.9		5.6		4.2		3.4		2.5		3.1		4.5		5		6.9		6.9		9.6		8.5	
total (incl.calm)	**29.5**		**24.3**		**18.8**		**16.1**		**14.1**		**16.9**		**21.9**		**24.6**		**25.2**		**26.4**		**34.6**		**32.6**	

2.2.3 Geological and Hydro-geological Characteristics

In general, the nature of rocks in this area is basaltic rocks, which is considered to be the upper limit of the Oligocene formations in Egypt. This basalt seems to belong to one of the magmatic activity; the hydro-thermal activities that accompanied this magmatic eruption seem to have long survived it.

The area under study is located in a zone that is geologically divided into two parts:

One. The Northern East Part

Granular Rocks

The type of rocks is low productive aquifer consisting of Quaternary and Tertiary sandy layers, local subsurface recharge from adjacent aquifer, insignificant surface recharge. This layer has a saturated thickness up to 250 m; the depth to groundwater head is from 25 to 100.

Lithology

The nature of rocks is coarse sands and gravel with limestone inter-beds (Miocene). The exposed thickness of the Miocene section ranges from 40 m east of Cairo (Middle Miocene) to more than 100 m west of Cairo (Lower Miocene, Moghra formation)

b. The Southwestern Part (where the site is located)

Granular Rocks

The type of rocks is non- aquiferous igneous or metamorphic rock. Local groundwater occurs in fissured or weathered zones. The saturated thickness is up to 40 m. these rocks may be permeable to water infiltrating from the Ismailia Canal.

Lithology

The nature of the rocks is basaltic rocks (Oligocene). The Oligocene sedimentary deposits consists of red colored sand and gravel, with some intercalation of clay and has a maximum thickness of about 100 m. Main out crops are located on the southeastern, along the Cairo-Suez desert road. Oligocene basalt is exposed in the Cairo area, at Abu Zaabal. The thickness of the basalt is variable and may reach 60 m. Recharge of the Tertiary and Cretaceous aquifers only take place through infiltration of rainfall and run off and by lateral inflow of groundwater.

Appendix C contains geological and hydrological maps of the region.

2.2.4 Geo-technical Characteristics

The soil stratification is relatively homogeneous and can be summarized as follows:

- A yellowish brown superficial layer that extends from 0.25 m to 1.00 m from the natural ground level. It consists of fill materials composed of a non-homogeneous mixture of sand, silt, gravel and broken sandstone.

- The surface layer is followed by a yellowish brown layer of cohesionless materials that consists of sandy silt or poorly graded sand intermingled with traces of calcareous pebbles and may contain traces to some fine gravel. The depth of this layer extends up to 4.45 except for bore-hole 7 where it extends to a depth of 7.45 from the natural ground surface. This layer is absent in some bore holes, e.g., bore holes No. 5, 8.

- The next layer is dark brown to black in color and is composed of highly weathered, cavernous, thinly laminated, gravelly sandstone that is considered moderately weak, to moderately hard, according to the Egyptian Code of practices (1995) classification. This layer extends up to 5.00 m deep from the natural ground surface, but may be absent in some locations.

- The last layer starts where most of the bore holes have been terminated. It has not been much penetrated due to the natural hardness of the basalt. Nevertheless, attempts have been made to penetrate the layer, which resulted in samples of hard cavernous basalt.

- In some locations, e.g., the location of bore hole 4, the basalt layer has not been reached, on the contrary, a yellowish brown silty clay layer appears prior to the termination of drilling at a depth of 15.0 m from the grounds surface.

The site is suitable for construction and its selection does not place unnecessary burdens on the site development. It also does not constrain or impose special distribution of land uses in the site. As a safety precaution, construction should commence at least 10 m away from the edge of the deep hole located south of the site. The groundwater table is very deep and is protected by a hard impermeable basalt layer.

Appendix D contains a soil field investigation report including general recommendations and ones for foundations, sequence of construction and concrete slab on grade.

2.2.5 Groundwater Quality

The quality of groundwater at the observation wells (existing at the south of the industrial area) has been studied. It was found that the concentration of thr total dissolved solids (TDS) in the observation wells range from less than 1000 ppm (fresh water) to between 1000-5000 ppm (brackish water). The chemical composition of groundwater is important for the determination of its suitability for a particular use. Groundwater quality reflects the geo-chemical and hydro-geological process to which the groundwater has been subjected.

Appendix E contains a map of the observation wells. Tables (2.3, 2.4) give data for observation wells.

Table (2.3) Data of Observation Wells

Well No.	Water Level Relative to MSL, m	Depth of Screen	Occurrence of Clay Layer, m	TDS
202C	-	56	-	1435
46	12.9	34	-	896
201	12.1	41	0- 21	748

Table (2.4) Chemical Analysis of Groundwater

Well No.	Na mg/ l	K mg/ l	Ca mg/ l	Mg mg/ l	HCO_3 mg/ l	CO_3 Mg/ l	Cl mg/ l	SO_4 Mg/ l	TDS mg/ l	SAR* mg/ l
202C	455	10.1	20.2	20.3	262	0	621	46.1	1435	6
46	170	11.7	48.4	26.2	464	0	142	33.6	896	1.7
201	130	10.1	38.4	40.6	311	12	195	10.1	748	1.2

* Sodium Adsorption Ratio

2.2.6 Air Quality

EEAA central laboratory had collected air samples and analyzed the ambient air pollutants at the dumpsite south of the designated site in Abu Zabaal. The following conclusions were reached, regarding the quality of air in the area compared to the limits of Law 4/94:

- Carbon monoxide (CO), sulfur dioxide (SO_2) and nitrogen dioxide (NO_2) concentrations were below those of Law 4/1994 limits.

Table (2.5) Measurements of CO Concentrations at the Dumpsite

Sampling Date	Max. 8 h Concentration (mg/m^3)		Average Daily Concentration (mg/m^3)
	Measured	Law Limit	
26/10/99	8.6	10	5.2
27/10/99	8.2	10	3.8
28/10/99	6	10	2.9

Table (2.6) Measurements of SO_2 Concentrations at the Dumpsite

Sampling Date	Max. Hourly Concentration (μg/m³)		Average 24 h Concentration (μg/m³)	
	Measured	Law Limit	Measured	Law Limit
26/10/99	62.9	350	2.9	150
27/10/99	65.7	350	36.3	150
28/10/99	51	350	25	150

Table (2.7) Measurements of NO_2 Concentrations at the Dumpsite

Sampling Date	Max. Hourly Concentration (μg/m³)		Average 24 h Concentration (μg/m³)	
	Measured	Law Limit	Measured	Law Limit
26/10/99	135.5	400	61	150
27/10/99	102.3	400	32.6	150
28/10/99	61.6	400	23.5	150

- The daily average concentration of the inhaled particulates (PM10) was higher than the allowed limit.

Table (2.8) Measurements of PM10 Concentrations at the Dumpsite

Sampling Date	Max. Measured Hourly Concentration (μg/m³)	Average 24 h Concentration (μg/m³)	
		Measured	Law Limit
26/10/99	166	76.9	70
27/10/99	202	76.9	70
28/10/99	168	88.3	70

- The ozone gas concentration rises beyond the allowable limit, and this allows for chemical reactions that result in secondary pollutants. This pollutant usually occurs at the early hours of the day and lasts until two or three o'clock in the afternoon. It causes blurring of vision and has negative impacts on the respiratory system and may cause other health problems.

Table (2.9) Measurements of O_3 Concentrations at the Dumpsite

Sampling Date	Max. Hourly Conc. (μg/m³)		Average Measured 24 h Concentration (μg/m³)	Average 8 hr. Concentration Law Limit (μg/m³)
	Measured	Law Limit		
26/10/99	248	200	125	120
27/10/99	139.3	200	58.5	120
28/10/99	206	200	82	120

CAIP had also collected air samples and analyzed the PM10 and lead in the ambient air at the Awadallah site. Refuse was not burned at the dumpsite site during October 25th sampling period. However, refuse was burned on October 26th and 27th when the very high PM10 levels were measured. The dumpsite area is adjacent to the Awadallah site, thus the site is heavily impacted by the smoke generated by refuse burning. The average of lead levels measured at the site was 0.65 $\mu g/m^3$. This level, if it prevails throughout the year, is well below the law limit of 1 $\mu g/m^3$ (annual average).

Table (2.10) CAIP PM10 and Lead Monitoring Data

Sampling Date	PM10 Conc. ($\mu g/m^3$)	Pb Conc. ($\mu g/m^3$)
25/10/99	453.6	0.35
26/10/99	2354.3	1.04
27/10/99	1379.0	0.56

From the analyses, it is clear that the background concentrations of pollutants are well below the allowable limits, except for the dumpsite area where PM10 concentrations exceed the allowable limit. It is thus important to upgrade the dumpsite before construction works begin.

2.3 Biological Environment

2.3.1 Flora and Field Crops

Vegetation around the relocated area of Abu Zaabal was divided into wild vegetation (flora) of the uncultivated land and field crops. Sixteen stands were set in and around the designated area, as well as around the agricultural area.

a. The flora

Vegetation in and around the designated area is representative of arid sub-Sahara and Sahara areas. A variety of grasses, shrubs and trees are scattered in the desert area. The survey findings had shown that the site is typical of the uncultivated land of Qalubiya province and is dominated by Phragmites australis, Juncus rigidus and/or Aster squamatus, Alhagi mourorum, Desmostachya bipinnata and/or Kochia indica, Conyza dioscroidis and Tamarix nilotica.

b. The field Crops

The relocation site is close to some agricultural lands. The nearest cultivated area is about 2 km away north-east of the site. The common field crops in the surrounding area are zea mays, rice, wheat, tomato, grape, barsim and citrus species, in addition to eucalyptus and date palm trees.

Appendix F contains details of the flora and field crops survey.

2.3.2 Fauna and Domestic Animals

The animal life in and around the relocated area was divided in the study into four zones. The designated area was represented by zone A, while zones B (2 km north of the site), C (4 km north of the site) and D (2 km south-west of the site) were neighboring agricultural areas to the site. The animals could be divided into wild animal life (fauna) and domestic animal life.

a. The Fauna

The wild animal life was recorded mainly in zone A. Common species of invertebrates (e.g. insects) and vertebrates (e.g. birds and mammals) of Egyptian Sahara are noticed and recorded in large numbers. A few number of kestrel (*falcon tinnuncalus*) which is considered a threatened species according to the EEAA bio-diversity report, was noticed in zone A. No domestic animals were found in zone A. However, few species, particularly wild birds and insects were found in zones B, C and D.

b. Domestic Animals

Domestic animals and poultry were recorded only in the agricultural areas of zones B, C and D. Common species of cattle, insects (e.g. bee, bugs and butterflies) and poultry have been noticed and recorded in the investigated zones of the agricultural area around the designated site. Large to small scale cattle and poultry farms are located in zone C. Few species of wild birds and other animals were found in the agricultural area such as the threatened kestrel.

Appendix G contains a detailed fauna and animal field survey.

2.3.3 Conclusion

The designated area of Abu Zaabal is part of the Belbeis Khanka desert and is not characterized by the presence of rare species of plants or threatened animal species, with the exception of the kestrel (*falcon tinnuncalus*), which is recorded as a threatened bird. Generally, the area is characterized by the common wild life of the Egyptian desert.

The surrounding agricultural land includes cultivation of field crops such as rice, wheat, barley, barsim, and citrus fruit. It also contains considerable numbers of livestock and poultry.

2.4 Social Environment

Based on the social survey that was presented by the Social Planning Analysis and Administrative Consultants (SPAAC), a number of concerns were deduced regarding the community of Shoubra El Kheima and that of Abu Zaabal.

2.4.1 Community of Shoubra El Kheima

Owners of small smelters and foundries should be provided with incentives to encourage them to relocate. They will probably refuse to relocate because of the costs. Moreover, the relocation of workers and their families is not an easy operation and they need to be motivated. Those who do not move will have to be compensated for the increased cost of transportation. Another challenge faced will be retraining workers to operate and maintain the new modern technologies.

Technical and financial assistance may have to be provided to the workers and foundries owners as an incentive to encourage them to relocate.

2.4.2 Community of Abu Zabaal

People at Abu Zabaal, especially residents of the adjacent communities to the site location, share negative attitudes of the relocation issue. They refuse the relocation of lead smelters close to their homes and reject the relocation of polluting industries in general. The main reasons behind their disapproval are the current pollution and living conditions that they are forced to endure, and a serious lack of confidence in the governorate executives.

Moreover, Abu Zabaal residents have already been suffering, for years, from the exposure to polluting industries, poor public utilities and poor public services. They also feel that before they can accept any new industries, or projects introduced to the area, current-deteriorating conditions need to be attended to. The existing major polluting industries are: the Fertilizer factory, the Alum factory, the dumpsite, over 50-100 unlicensed polluting cast-iron factories in Al Akrasha, the Slaughter house and the Ceramic factory.

Social resistance can be decreased through introducing the people to the proposed new technologies used to minimize emissions that cause health hazards to adjacent residents and assuring them of the monitoring devices and procedures and the appropriateness of the location vis-a vis existing settlers. Proper site planning as well as the provision of new employment opportunities and improvement of services in the area should also be stressed.

2.5 Legislative and Regulatory Consideration

As a basis for the proposed development, a survey of the relevant legislation and regulations was conducted. Relevant laws included those of the environment, labor conditions, urban planning, those governing disposal of liquid waste and protection of water ways from pollution as well as the decrees concerning the specifications and requirements for foundries and smelters and others regarding establishment of sites and liscencing conditions.

The regulations related to industrial environmental performance as well as those related to industrial location and building conditions are identified in *Appendix H.*

Chapter 3
Description of Foundries Technologies

This chapter is an analysis of the technologies currently used in Shoubra El Kheima and their associated pollution loads. Modern technologies and control measures are also discussed.

It was concluded that:

- Shoubra ElKheima foundries should not be relocated in the new site in their current non-compliant status.

- Compliance with environmental regulations could be achieved through adopting available tested modern technologies and implementing efficient control measures, requiring no substantial changes in current production practices.

- Although the melting stage is considered as the principal source of pollution, especially air pollution, in a foundry, other stages such as raw material preparation and product finishing processes greatly contribute to the extent of pollution resulting from the foundry.

- This chapter provides quantified inputs (such as raw materials, water, and energy) and outputs (wastewater, gaseous emissions and solid wastes) for the foundries which provides inputs to the following chapters.

- All calculations for the industrial estate are made assuming its production capacity to be completed (as listed in chapter 1). However, it should be stated that the capacity figures are 2-3 times higher than the current production of Shoubra El Kheima foundries to be relocated.

3.1 Iron, Copper and Aluminium Foundries

3.1.1 Process Description

Secondary metal processing may be described as the processing of metal containing materials to recover the metal. The metal is melted and heated to a certain temperature in order to reach the required chemical composition and quality. The molten is poured into a mold and left to cool and solidify to form the casting. Finally, the casting is removed from the mold, cleaned and subjected to further treatment if necessary.

Several casting processes are used to produce castings of different shapes, sizes and masses. The basic molding process is “sand-mold casting” which is used to produce about 80% of the castings. However, in many cases, the casting dimensional accuracy and surface finishing do not satisfy the requirements of modern machine fabrication and instrument making industries, which gave way to using other processes such as permanent-mold casting, die casting, shell casting, centrifugal casting and investment casting (lost wax method). These processes produce castings of high dimensional accuracy and low surface roughness.

As shown in fig (3.1), the main foundry operations are:

1. Handling, preparation and treatment of raw material
2. Preparation of molding and core making mixtures
3. Pattern manufacturing
4. Mold and core making as well as finishing
5. Metal and scrap dosing, charging, melting, refining and alloying
6. Pouring and cooling
7. Castings shakeout and core knockout
8. Cleaning and finishing of castings
9. Heat treatment
10. Machining and painting
11. Used sand refreshing and reclamation.

Other foundry operations include quality control, equipment maintenance, and transportation of raw materials and wastes.

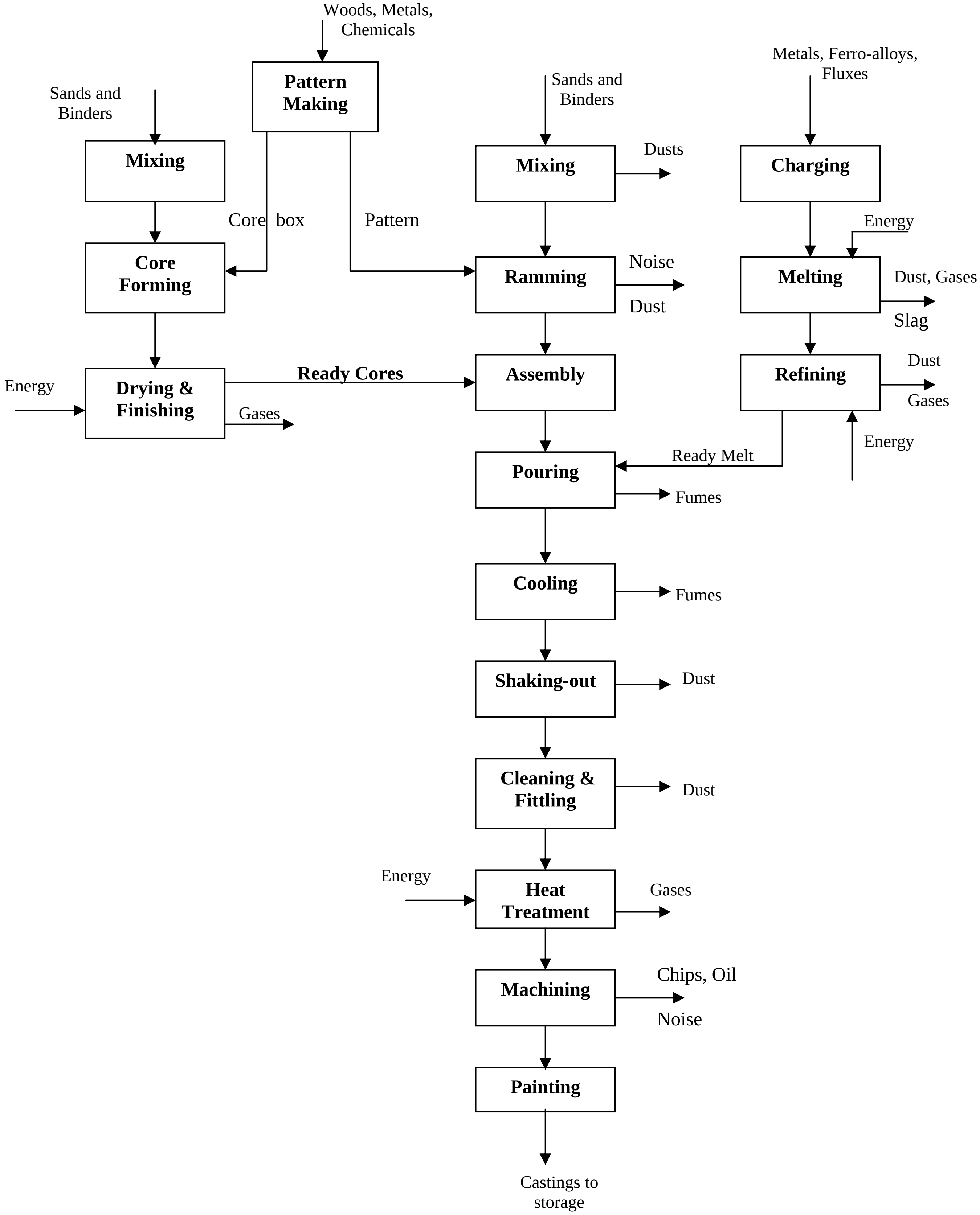

Fig. (3.1) Main Foundry Processes

a. Pattern Making

The pattern is the solid part used to define the shape of the casting inside the mold. It is usually made of wood, and sometimes of other materials like metals (bronze, aluminum), plastics, epoxy resin, gypsum or cement. The required accuracy, strength, and life of the pattern depend on the production capacity. Wood patterns are usually used for small scale production while metal patterns are preferable in the large scale and mass production, since they are more durable than wood.

b. Molding and Core Making

Various types of material are used in foundries for the manufacture of casting molds and cores. They are divided into primary molding materials, molding and core mixtures, as well as auxiliary molding mixtures. Primary materials include sands such (shell sand, oil sand, CO_2 sand[1], etc.) and binders, such as clays and resins. Auxiliary materials include various additives such as coal dust, wood dust, and other materials that add desired properties to molding and core sands.

Molding and core mixtures are prepared from primary molding materials and reclaimed sands. Cores are used to create holes or cavities in the castings. They are prepared in a similar way as sand molds by mixing or mulling then packing in a core box. Cores mixtures are mainly composed of sand and binding materials such as oils, resins, organic binders, cement and sodium silicates. Sand is either mixed with the binders in the foundry or purchased with the binder already included as sand grain coating as in the case of shell core sand. A core must have high gas permeability, high strength, as well as good formability and collapsibility. Cores are manually or mechanically made in core boxes or using templates. It is preferable to use machine molding, which requires less manpower than other methods, and produces precise molds. Usually, high levels of noise are produced especially when jolting squeezing machines are used.

Tables (3.1a,b,c) give the material consumption for molding and core making in iron, aluminium and copper foundries respectively. Curing using organic binders, liquid or solid carbonaceous resins, can be performed by baking at about 200-316°C or by using catalysts at ambient temperatures. The main cure reactions include polymerization and oxidation. Curing is followed by thermal degradation as a result of the high temperature of the molten, these two processes are responsible for sand waste in the foundry. Sand falling on the ground during handling and core making is swept and disposed of.

[1] The sand is subjected to carbon dioxide after ramming for quick solidification. This method is used when molds and cores are needed quickly.

Table (3.1a) Material Consumption for Molding and Core Making Operations in Iron Foundries

Material	Rate in kg/ ton Castings
Molding Material	**129**
- New sand	72
- Clays (Bentonite)	33
- Carbon (Coal dust)	24
Core Materials	**352**
- Shell Sand	27
- Others (e.g. resins, wax)	54
- Sand Oil	230
- CO_2 Sand	41
Subtotal (Sand , binders and Additives)*	**481**

* The above figures reflect the amount of sand make-up which is about 10% of the total sand used in iron foundries

Table (3.1b) Material Consumption for Molding and Core Making Operations in Aluminum Foundries

Material	Rate in kg/ ton of Castings
Molding Sand	**343**
- New Sand	246
- Clay	53
- Carbon	44
Core Material	**2812**
- Shell sand	158
- Others	10
- Sand oil	1127
- CO_2 oil	1517

Table (3.1c) Material Consumption for Molding and Core Making Operations in Copper Foundries

Material	Rate in kg/ ton castings
1. Molding Material	**931**
- New Sand	745
- Clay	186
2. Core Making Material	**1255**
-Shell Sand	490
-Others	672
-CO_2	93

c. Melting

Several raw materials are used in the melting process. Usually, the charge includes pigs, scrap, rejects, chips, as well as fluxes. These materials are mixed according to the required charge composition. The melt is heated in the furnace to a certain temperature in order to reach the required fluidity for proper mold filling. The metal is then poured into ladles to be transported to the pouring unit where the metal is poured in molds and left to cool. Several types of furnaces such as crucible, reverbatory, cupola (shaft furnace), rotary and induction furnaces are used in foundries.

Cupola Furnace

The cupola is a vertical cylindrical shaft furnace that is usually used in iron foundries. The mechanism by which melting is accomplished is heat release through the combustion of fuel (coke, liquid fuel or gaseous fuel) that is in direct contact with the metallic portion of the charge. In cupola furnace, coke is either used as a fuel or as a process additive with liquid or gaseous fuels to increase the percentage of carbon in the metal.

One of the advantages of such furnaces is that counter-flow preheating of the charge is an inherent part of the melting process where the upward flowing hot gases come in close contact with the descending charge, allowing direct and efficient heat exchange to take place. The main disadvantage of using coke, about 3% sulfur content, as a fuel is the emission of high sulfur dioxide concentrations and thus it is preferable to use liquid or gaseous fuel.

Rotary Furnace

They are usually directly fired by a burner using liquid or gaseous fuel. The furnace can be used for melting charges in all foundries.

Crucible Furnace

Indirect-fired crucible furnaces are usually used in copper and aluminium foundries with small and medium production. Before any metal is added to the crucible, fluxes should be added so that, as melting takes place, a cover is formed to keep the molten metal separated from the atmosphere.

Induction Furnaces

Induction furnaces are either horizontal or vertical, cylindrical, refractory-lined vessels. Heating and melting occur when the charge is energized with an alternating current. The heating is rapid and uniform and the metal temperature can be accurately controlled. Induction furnaces generally have lower emissions per ton of metal melted than the other furnaces types.

The induction furnace has many advantages such as:

- Least in refractories consumption
- Least in slag production
- Easier and safer to use and control
- Least in emissions
- Least in running cost per ton of melt
- Low water consumption (closed circuit)
- Gives high quality of products

Tables (3.2a,b,c) give the material and energy requirements for the different melting technologies per ton of iron, aluminium and copper respectively.

Table (3.2a) Melting of Iron Castings
(Balance for 1 ton)

Item	**Melting Unit***		
	Induction	**Cupola**	**Rotary**
Energy:			
Electricity (kWh/ton).	600-800	20-40**	30-50
Coke (kg /ton)	-----	100-180	-----
N.G (m^3/ton) or Liquid Fuel (kg/ton)	40-60	40-60	140-230
Equivalent kWh***	**1060-1490**	**1644-3160**	**1654-2718**
Charging Materials kg/ton			
Steel Scrap	500-700	0-400	500-1000
Iron Scrap and Rejects	100-400	300-600	300-500
Pig Iron	150-300	150-500	-----
Fluxes: (kg/ton)			
Limestone	0-7	30-50	30-50
Fluorspar	0-3	0-3	0-3
Refractories (kg/ton)	3-5	20-30	25-35
Ferro Alloys: (kg/ton)			
Fe- Si	25-35(75% Si)	10-35 (45% Si)	35-70 (75% Si)
Others	50-100	30-70	-----
Carbonizer	30-40	-----	40-80
Water : (m^3/ton)			
Scrubber	4-6	4-8	4
Cooling	1-3	2-4****	-----

* References for these figures are given at the end of the report. Figures were selected from these references based on experience

** Source: Platonove, Induction Furnaces for Iron Foundries, 1976

*** Assuming 1 kg liquid fuel ≅ 1 kg coke ≅ 1m^3 of gaseous fuel ≅ 11.6 kWh.

***** Source: Gerchoveh, Iron Castings Handbook, 1978

Table (3.2b) Melting of Aluminum Alloys
(Balance for 1 ton)

Item	Melting Unit		
	Induction	Crucible	Rotary
Energy:			
Electricity (kWh)/ton	200-300	4-6	4-6
N.G (m^3/ton) or Liquid Fuel (kg/ton)	6-10	50-80	50 - 60
Equivalent kWh	270-416	584-934	584-702
Charging Materials (Kg/ton):			
Al. Pigs	600-800	700-900	700-900
Al. Scrap and rejects	100-200	100-300	100-300
Al Alloys: (Kg/ ton).			
Al- Si	200-300	200-300	250-350
Al- Cu	50-100	50-100	50-100
Al- Mg	20-40	20-40	20-40
Other Kg/ton	100-300	100-300	100-300
Refractories : (Kg/ ton)	5-10	15-25	20-30
Water (m^3/ton)			
Scrubber	2-4	2-4	3-5
Cooling	1-2	2-4	

Table (3.2c) Melting of Copper Alloys
(Balance for 1 ton)

Item	Melting Unit		
	Induction	Crucible	Rotary
Energy:			
Electricity (kWh)	380-500	4-6	4-6
Liquid Fuel Kg/ ton or N.G m^3/t	20-40	100-140	100-120
Charging Materials:			
Copper	300-600	300-500	300-500
Bronze	100-200	100-200	100-200
Brass	100-200	100-200	100-200
Foundry Returns	100-150	200-300	200-300
Cu . Alloys: (Kg/ ton)**			
Tin	20-140	20-140	20-150
Zn	40-50	40-50	40-60
Pd	5-20	5-20	5-25
Ni	10-20	10-20	10-20
P	5-10	5-10	5-12
Al	80-100	80-100	100-120
Si	20-30	20-30	25-35
Refractories : kg/ton	10-20	30-73	30-73
Water (kg/ton):			
Scrubber	2-4	2-4	3-5
Cooling	1-2	2-4	

* Elements in alloys

d. Shakeout and Cleaning

After cooling, the mold is broken and the casting is shaken out. This process may be performed either manually or mechanically. Gates, fins are removed and the surface of the casting is cleaned manually or mechanically using shot-blast machines or tumbling barrels. Table (3.3) gives the amount of cleaning materials used in the foundries.

Table (3.3) Material Consumption for Cleaning Operations

Material	Material Consumption per ton casting		
	Iron Foundry	**Copper Foundry**	**Aluminium Foundry**
Grinding	1	1	1
Steel Shots	3	14	51
Others (cleaning discs, surface cleaning	40	---	---

To obtain the required structure and mechanical properties of castings and to relieve internal stresses, the castings are sometimes subjected to heat treatment in ovens for a certain period of time. Sand castings are then cleaned again and checked for quality. Sometimes, castings are subjected to machining and painting to protect them against corrosion.

3.1.2 Water Consumption

Water consumption varies widely from one foundry to another. In the foundries, water is mainly used for cooling purposes. Uses of water are shown in the following:

a. Melting Stage

Water is used in cooling furnaces, wet-scrubbers, slag conveying, quenching of melt spills and housekeeping.

b. Molding and Core Making

Water is used in sand preparation, wet dust collectors, wet sand reclaim, core binders and chemicals, hydraulic system, cooling and housekeeping. The maximum water needed for sand preparation is about 10% of the total sand used.

c. Cleaning and Finishing

Water is used in wet blast system, painting, wet dust collectors, heat treating and quenching, cooling of machines and housekeeping.

d. General Use

Boiler feed water, air compressor cooling, domestic services, drinking water and irrigation.

3.1.3 Energy Consumption in Foundries

Data has shown that energy consumed in molding accounts for 7 to 20 % of the total energy consumed in the entire foundry. This percentage depends on many factors, such as the type of product, metal and size of the foundry itself. When using cupola and induction furnaces, reference have shown that the energy consumption of molding and core making is about 14.9%, of the total energy consumed in the foundry, for foundries similar to those relocated in Abu Zaabal.

Considering mold/core processes, each process has its own energy consumption that should be calculated before selecting a molding technique. A typical green sand molding operation consumes a considerable amount of energy in sand preparation, transportation of sand to the molding area, handling of molds and cores, shaking-out of castings and their transportation to the finishing area. Reclamation, reconditioning and recycling of sand are also factors that affect energy consumption in green sand molding system since there are a lot of interdependent functions in this system.

Liquid fuel or/and gas fuel may also be used in mold and core making. The energy consumption in shell molding is about 30% of that in green molding. Tables (3.4a,b,c) give the energy distribution in iron aluminium and copper foundries respectively.

Table (3.4a) Energy Distribution in Iron Foundries

Operation	Energy distribution in foundries in kWh/t		
	Cupola Furnace	Induction Furnace	Rotary Furnace
Melting	1644-3160	1060-1490	1654-2718
Molding and core making	483-668	795-1117	486-575
Pollution control	206-302	371-527	207-260
Casting shakeout and cleaning	302	371-522	207-260
Other	30-81	53-75	31-70
Total	2569-4513	2650-3725	2585-3883

Data in the above table shows that the total energy consumed in iron foundries, using sand molding, ranges from 2569 to 3883 kWh/t of casting. Foundries using short rotary furnaces (SRF) have the maximum energy consumption due to high fuel consumption.

Table (3.4b) Energy Distribution in Aluminium Foundries

Operation	Energy distribution in kWh/t		
	Induction	Crucible	Rotary
Melting	270-416	584-934	584-702
Molding of core making	483-668	483-668	483-668
Pollution control	52-60	52-60	52-60
Casting, shaking out and cleaning	82-121	82-121	82-121
Others	30-81	30-81	30-81
Total	917-1346	1231-1864	1231-1232

Table (3.4c) Energy Distribution in Copper Foundries

Item	Energy in kWh/t		
	Induction	Crucible	Rotary
Melting	612-964	816-1398	1164-1398
Molding & core making	483-668	483-668	483-668
Pollution control	52-60	52-60	52-60
Casting shaking out & cleaning	82-121	82-121	82-121
Others	30-81	30-81	30-81
Total	1379-2094	1811-2560	1811-2328

The total energy consumption in iron, aluminium and copper foundries are shown in tables (3.5a,b,c).

Table (3.5a) Total Energy Consumption in Iron Foundries

Item	Energy for foundries using		
	Cupola	Induction	Rotary
Electricity kWh/t	771-1497	2012-2797	961-1216
Coke Kg/t	100-180	-	-
Liquid fuel kg/t or N.G	40-60	40-60	140-230
Equivalent kWh/t	2569-4513	2650-3725	2585-3883

Table (3.5b) Total Energy Consumption in Aluminium Foundries

Energy	Energy for foundries using		
	Induction	Crucible	Rotary
Electricity kWh/t	847-1230	647-930	647-930
Oil or N.G kg/t	6-10	50-80	50-60
Equivalent kwh/t	917-1346	1227-1828	1227-1926

Table (3.5c) Total Energy Consumption in Copper Foundries

Energy	Energy for foundries using		
	Induction	Crucible	Rotary
Electricity kwh/t	1147-1630	651-936	651-936
Oil or N.G fuel	20-40	100-140	100-120
Equivalant kwh/t	1379-2094	1811-2560	1811-2328

3.1.4 Solid Wastes

a. Slag

Rotary furnaces produce the highest amount of slag among other types of furnaces due to the low-grade charges and high percentage of impurities. Oxides are formed as a result of melting metals and fluxes are added to separate these oxides in the form of slag and dross. Usually calcium carbonate (limestone) is added to the furnace charge as a fluxing agent in order to reduce the melting point of slag, such that the produced slag is of the required viscosity and fluidity, and to remove ash, resulting from burning the fuel, that goes out with slag. Limestone reacts with the sulfur in the fuel to form calcium sulfide that is one of the constituents of slag. Slag solidifies as a glass solid.

The amount of slag depends on the furnace used and casting produced. In case of induction furnaces, the amount of slag is about 25-50 kg/ton casting and 120-170 kg/ton in case of rotary furnaces. Table (3.5) gives the amount of slag produced from iron, copper and aluminium foundries.

Table (3.6) Amount of Slag Produced from the Foundries (kg/ ton Product)

Foundry	Induction Furnace	Cupola Furnace	Crucible Furnace	Rotary Furnace
Iron Foundry	25-50	100-150	-----	120-170
Copper Foundry	2-4	-----	2-5	2-6
Aluminium Foundry	3	-----	3	10

b. Dust

Dust is produced from the following areas:

- Melting units, molten metal treatment.
- Pouring area shakeout cleaning of castings, grinding, blasting, molding, sand preparation handling of sand, raw materials and sand mixtures
- Dust, collected by scrubbers, cyclones and filters, is disposed of. Sometimes dust resulting from sand preparation unit is added to sand. This dust has a high content of coal dust and bentonite.

Table (3.7) gives the amount of dust produced from iron, copper and aluminium foundries.

Table (3.7) Amount of Dust Produced from the Foundries (kg/ ton Product)

Foundry	Induction Furnace	Cupola Furnace	Crucible Furnace	Rotary Furnace
Iron Foundry	3-5	4-8	-----	10-15
Copper Foundry	1-2	-----	1-2	4
Aluminium Foundry	2-4	-----	2-4	2-4

c. Sand

Used sand, core sweepings and butts are about 65-78% of the total solid waste from iron, aluminium and copper foundries. When cores are exposed to the molten, they lose their strength due to thermal degradation (480-540 °C) and the sand falls away from the castings in the shakeout and mixes with the molding sand. After shakeout, the chunks are separated from the molding sand and disposed of together with broken cores.

Although the process in all ferrous and non-ferrous foundries are similar yet the metallic droppings in waste sand from non-ferrous foundries are not readily separated from the sand and thus can not be recycled and are usually disposed of. To benefit from these droppings, sand should be reclaimed in the foundry and this is usually performed by means of manual screening, a very tedious operation. In ferrous foundries, these metallic droppings are separated using magnets and the sand is screened and processed, in order to be used once more. Tables (3.8a,b,c) show the amount of waste sand mixtures in iron, aluminium and copper foundries respectively.

Table (3.8a) Molding and Cleaning Wastes in Iron Foundries

Material	Rate in kg/ ton of Castings
Sand System	**385**
- Molding sand	208
- Degraded Shell	6
- Degraded Core Sand	11
- Degraded Oil	49
- Degraded CO_2	9
- Core Butts*	75
- Core Room Sweepings	27
Cleaning Room Waste	**4**
- Grinding	0.5
- Steel Shot	3
- Others	0.5
Total	**389**

* Core butts are remnants of cores that were not degraded

Table (3.8b) Molding and Cleaning Wastes in Aluminum Foundries

Waste	Rate in kg/ ton Castings
Sand System	**2480**
- Degraded Shell	40
- Degraded Oil	253
- Core Butts	2158
- Core Room Sweepings	29
Cleaning Room Waste	**14**
- Grinding	1
- Shots	13
Total	**2494**

Table (3.8c) Molding and Cleaning Wastes in Copper Foundries

Material	Rate in kg/ ton castings
Sand System	**1627**
- Degraded Shell	800
- Core Butts	**827**
- Core Room Sweepings	500
- Degraded Shell	27
	300
Cleaning Room Waste	**13**
- Grinding	1
- Shots	12
Total	**1640**

3.1.5 Gaseous Emissions

Gaseous emissions due to the combustion process in the furnace include carbon monoxide, carbon dioxide, sulfur dioxide and nitrogen oxides. Other gaseous emissions from the furnace include metal oxides such as aluminium, silicon, copper, magnesium and zinc particulates. Table (3.9) gives the amount of gaseous emissions produced per ton product of iron, copper and aluminium castings.

Table (3.9) Amount of Flue Gases Produced from the Furnaces (in kg/ ton Product)

Foundry	Induction Furnace	Cupola Furnace	Crucible Furnace	Rotary Furnace
Iron Foundry	20-50	1500-2500	-----	1500-2500
Copper Foundry	20-30	-----	1400-1800	1400-1800
Aluminium Foundry	15-20	-----	600-1000	600-1000

One source of fugitive emissions is charging scrap into furnaces containing molten metals. This often occurs when the scrap being processed is not sufficiently compacted to allow a full charge to fit into the furnace prior to heating. The introduction of additional material onto the liquid metal surface produces significant amounts of fumes and smoke, which can escape through the charging door. Briquetting the charge offers a way to avoid fractional charges. When fractional charging cannot be eliminated, fugitive emissions can be reduced by shutting-off the furnace burners during charging. Fugitive emissions may also evolve during pouring the metal.

3.1.6 Control Equipment

a. Cyclones

Cyclones are usually used to separate large dust particles from gaseous streams. They are usually used for the cupola furnace where gaseous emissions are passed through the cyclone before being directed to the wet scrubber or bag filter.

b. Wet Scrubbers

Wet scrubbing is used to control both particulate and gaseous emissions simultaneously, to control acid gases such as sulfur dioxide, to scrub particulates from exhausts and to control metallic powder such as aluminium dust. The types of wet scrubbers include venturi scrubbers, mechanically aided scrubbers, pump-aided scrubbers, wetted filter scrubbers, tray or sieve-type scrubbers.

Particles are captured in the liquid phase forming water droplets and separating the droplets from the gas stream. In case of induction furnaces, the rate of flue gases emitted is relatively low and the wet scrubber may be used for cleaning flue gases from other sources as well.

c. Bag Filters

Dry collectors include bag-house especially the Teflon-coated woven glass fiber bags that have been used successfully on a large majority of cupola furnaces because of their high temperature resistance. Wet scrubbers are usually preferred by foundries owners due to their low cost compared to bag filters.

d. Controlling Fugitive Emissions (Industrial Ventilation)

The system usually consists of three components; a hood or enclosure, to capture emissions that escape from the process, a dust collector, that separates entrained particulate from the captured gas stream, and a ducting or ventilation system, to transport the gas stream from the hood or enclosure to the air pollution control device.

3.2 Secondary Lead Smelters

3.2.1 Process Description of Secondary Lead Smelters

Secondary lead smelting is essentially a battery recycling industry, characterized as follows:

- About 90% of the lead-bearing raw materials at a secondary lead smelter are from lead-acid batteries used in automobiles or industry.
- About 98% of all lead acid batteries are recycled at secondary lead smelters, which represent the only acceptable disposal option for used batteries.

The process consists of five main sections, as shown in the descriptive process block diagram (fig 3.2). Each of these sections is described below.

a. Batteries Storage

Dry lead acid batteries are stored in an open area, prior to processing, with other solid raw materials. Sulfuric acid (12 - 18%) is drained elsewhere, within the scrap battery collection network, before reaching the plant.

b. Batteries Processing

The recycled batteries are primarily broken up manually or by using automatic cutters to separate the plastic and metallic parts from lead-bearing parts. The plastic parts are about 16-20% of the battery weight. Separation of plastic parts is very important because if these parts are burned, toxic chlorine gas is produced.

c. Smelting furnaces

Battery plates and groups are loaded on small barrows to be manually charged into the smelting furnace where lead is extracted from lead components. Charging is usually done, manually, in batches using shovels and takes about an hour. Fluxing agents such as soda ash (Na_2CO_3) or limestone ($CaCO_3$) are fed with the lead-bearing scrap materials to the furnaces to promote the conversion of lead oxide and other lead compounds to lead metal and to fixate acid gases (Cl_2, HCl) as they react with these gases forming $NaCl$ and $CaCl_2$ that are discharged with the slag. Iron can also be added to fix sulfur as ferrous sulfides. There are two types of furnaces used for smelting; blast and rotary furnaces.

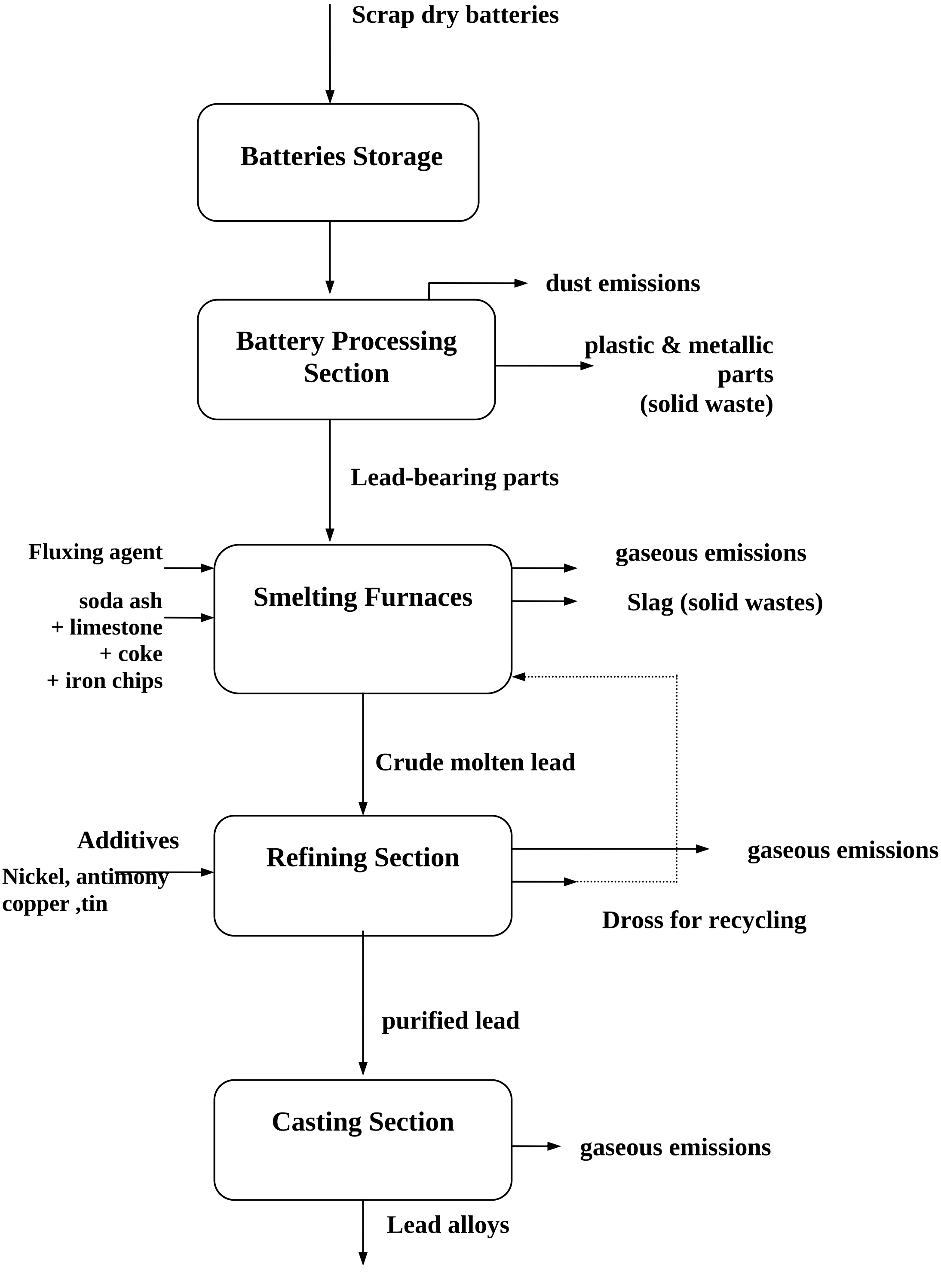

Fig. (3.2) Secondary Lead Smelters Processes

Blast Furnace

The blast furnace is a vertical steel cylinder lined with refractory brick. Foundry coke is used in the blast furnace as a fuel and to form (CO), either directly through the partial oxidation of coke to CO (carbon monoxide) or in two steps, through the complete combustion of coke to CO_2, which will react with coke to produce CO. CO reduces lead oxides to lead. The exhaust gas from the blast furnace is within the temperature range of 500-600 °C, and always contains three classes of HAPs:

- Lead and traces of other heavy metals
- Organic hazardous air pollutants (HAPs)
- Acid gases (Cl_2, HCl and chlorinated hydrocarbons)

Blast furnaces are usually followed by after burners in order to destroy harmful chemicals.

Rotary Furnace

The rotary furnace is a horizontal shell lined with refractory brick and is fired directly with solar or fuel oil. The furnace is usually equipped with variable speed drives to control the rate of rotation. After stopping the burner and the rotation, a side spout is opened to discharge the slag formed at the surface of the liquid metal. The liquid metal is then poured into a ladle.

The main advantage of the rotary furnace is the high temperature of exhaust gases that ranges from 1000-1200 °C. This high temperature destroys organic HAPs, and the relatively large amount of fluxing agents (as compared with fluxing agents used in the blast furnace) ensures the fixation of the acid gases into the slag. Consequently, rotary furnaces are not sources of organic HAPs or acid gases.

Both types of furnaces (blast and rotary) are usually equipped with bag filters to capture the fine solid particles, particulate matter and recycle it with the feed to the furnaces.

d. Refining Section

The lead tapped from smelting furnaces is refined and alloyed in open-top refining kettles that are heated from underneath by gas-fired burners to 400°C. Impurities are then removed from the molten lead as dross that floats on the surface of the lead. The dross is usually recycled back to the furnace. Different alloys can be formed using lead and other metals such as antimony, tin, copper and nickel.

e. Casting Section

The casting section is where lead is molded into ingots or other required shapes. The ingots are stored at the smelter before being shipped to the customer or transferred to battery manufacturing facility.

Table (3.10) Material and Energy Requirements for Lead Furnaces (Balance for 1 ton)

Item	Consumption
Energy	
Electricity (K.W. hr)/ton	38
Liquid Fuel (kg/ton)	200
Charging Materials (kg/ton)	
Dry Batteries Scrap	1310
Fluxes (kg/ton)	
Soda Ash	66
Coal Fines	50
Steel Shavings	50
Cooling Water* (m^3/ton)	0.314

* only for blast furnaces

3.2.2 Solid Waste

The main solid waste for secondary lead smelters is slag. Analyses were performed for the slag generated from lead smelters in Egypt and the results showed that the slag is not considered hazardous since lead concentration in the slag is less than 2% qualifying it as non-hazardous according to EPA.

Other solid wastes include the plastic and rubber parts of the battery that are separated before melting. Flue dust collected by bag houses and dross removed from refining kettles are recycled on site to the smelting furnace at all smelters and is not disposed of as solid waste. Table (3.11) give the amounts of solid wastes produced in a lead smelter per ton product.

Table (3.11) Solid Waste Produced in a Secondary Lead Smelter

Wastes	Amount of Waste in kg/ton product
Plastic Chips (kg/ton)	41.8
Rubber Chips (kg/ton)	47.5
Slag (kg/ton)	157.2

3.2.3 Gaseous Emissions

The most important are the exhaust gases from the smelting furnaces. Emissions from the furnace are about 1000 kg/ton product. The emissions include:

- Metal oxides such as lead
- Organic compounds (emitted only in case of blast furnace) such as benzene, CS_2, CH_3Cl, 1-3 Butadiene, styrene, toluene,

formaldehyde, naphthalene, etc. They include also toxics such as dioxins, furans etc. These are usually controlled through thermal destruction.

- Acid Gases such as sulfur dioxide, chlorine, hydrogen chloride and chlorinated hydrocarbons that result from plastics (PVC) and other polymers in the charge. They are usually controlled by means of fluxing agents.

3.2.4 Control Equipment

a. Afterburners

Exhaust gases from the blast furnace is usually directed to an afterburner to destroy organic hazardous air pollutants, control carbon monoxide emissions and burn carbon which facilitates collection and handling of dust particles within dry type collectors down stream. An afterburner operating at 700 °C controls an estimated 84% of the total organic pollutants.

b. Dust Collectors

Baghouses are usually used to control particulate matter and lead dusts. Properly maintained baghouses are capable of achieving greater than 99% control of PM and 98% control of lead and other metal.

Analyses performed by Air Quality Monitoring Component (AQMC) for CAIP in Awadallah smelter in 10^{th} of Ramadan in August 1999, had shown that high removal efficiency could be achieved, such that the lead concentration is reduced below the allowable limit of law 4/1994(20 mg/m^3). The control system in this smelter consists of hoods and fans to capture fugitive emissions from the furnace. The captured emissions are mixed with the flue gases in a duct and cooled in a cooling chamber to reduce the emissions temperature. After cooling, the gases are injected with lime to reduce sulfur dioxide. Gases are then directed to a cyclone to separate large dust particles prior to the bag house. The gases temperature (120-130°C) is higher than sulfur dew point thus avoiding corrosion of the bag house.

3.3 Current Status of Shoubra El Kheima Foundries

A survey was conducted for Shoubra El Kheima foundries. Information was gathered for 12 ferrous foundries and 5 non-ferrous foundries. The data collected included:

- Foundry general information (actual and nominal capacities, number of workers, type of production, etc.)
- Technologies applied in the different production units
- Material and energy consumption
- Wastes and emissions

- Recycled material

Tables (3.12 & 3.13) give the basic information for ferrous and non-ferrous foundries respectively.

Table (3.12) Survey Results for Ferrous Foundries in Shoubra El Kheima

Main Equipment used		**Types of Products**	**No of Workers**	**Nominal Capacity (ton/year)**	Actual Production **(ton/year)**	**Foundry No**
Forming	**Melting**					
- 25 Centrifugal Casting Machine - Automatic Molding Line - Sand Preparation Unit	- 2 Induction Furnaces (2.5 ton/ hr)	Iron pipes, Sanitary Castings, Other Iron Castings	100	10,000	9,000	1.
- Centrifugal Casting Machine - Jolting Squeezing - Sand Preparation Unit.	- 2 Cupola Furnaces (3.5 ton/h) - Induction Furnace	Joints, Iron Pipes.	90	8,000	7,000	2.
- 4 Centrifugal Casting Machine - Sand Shell Molding Machine - Automatic Molding Machine	- 2 Induction Furnaces (0.5 ton/h) - 4 Induction Furnaces (0.25 ton/h) - 2 Cupolas (2 ton/h)	Sanitary Iron Castings, Pipes Elbows, Steel Castings	60	3,500	3,000	3.
- Molding machine - Sand Preparation Unit	- Cupola (5ton/h) - Cupola (2.5 ton/h)	Sanitary Iron Castings, Pumps, Valves	35	3,000	2,500	4.
- Centrifugal Casting Machine - Sand preparation Unit - Automatic Molding Machine	2 Cupolas (1ton/h)	Pipes, pipe joints	100	2500	1000	5.
Centrifugal Casting Machine	2 Cupolas	Sanitary Iron Pipes	40	2350	2000	6.
---	2 Cupolas	Sanitary Iron Casting	25	2000	1200	7.
- 8 Molding Machine - Coating - Prying Furnace	- 1 Cupolas (2 ton/h) - 1 Cupola (1.5 ton/h) - Crucible Furnace	Iron Castings, Copper alloys	60	1500	1000	8.
2 Molding Machines	1 Cupola (1ton/h)	Gray Iron Castings	50	1200	1100	9.
Molding Machines	1 Cupola (1ton/h)	Gray Iron Castings	45	980	800	10
Workshop For Machining	1 Cupola (1ton/h)	Pumps + Valves	30	800	700	11.
-----	Cupola (1ton/h)	Sanitary Castings	35	800	750	12.

Table (3.13) Survey Results for Non Ferrous Foundries in Shoubra El Kheima

Main Equipment: Molding	Main Equipment: Furnaces	Types of Products	No. of workers	Nominal Production t/y	Actual Production t/y	No.
- Hydraulic Press - Continuous Casting	4 Crucibles + Induction Furnace	Copper pipes	50	3000	1000	1.
		Copper pipes	30	1300	1000	2.
	4 Crucible Furnace	Pipes Castings	25	800	500	3.
	3 Induction (0.75t)	Castings	20	500	300	4.
	3 Crucible Furnace	Castings	15	500	200	5.

The survey has shown that:

1. Most of Shoubra El Kheima foundries were founded years ago with no changes in their area or technology. Thus, they have small areas compared to their production volume and are crowded with raw materials and products. They are found in residential areas between hospitals, schools and houses.

2. Rusty and dirty low quality raw materials are used without any primary treatment. In most foundries, operations (loading, unloading, handling of raw materials and products) are manual due to the availability of cheap labor.

3. Pollution levels are extremely high in the working area and outdoors. This is due to:

   - Using cupola furnaces in iron foundries without any control equipment
   - Using low quality charging metals and scraps with no pretreatment. The charge is full of dust, oxides, grease, oils, non- metals and other impurities that contaminate the melt or evaporate forming metal vapors.
   - Using low quality fuel such as coke and fuel oil; both of which are contaminated with ash and sulfur.
   - Using non-foundry sands and binders.
   - Absence of air cleaning systems in most foundries and poor ventilation in working area.
   - Lack of quality control systems.

It is worth mentioning that some foundries began to implement pollution control measures and equipment, yet most implemented equipment are of low efficiency. No measures were taken to improve working conditions.

4. Only 3% of Shoubra's foundries use induction furnaces, which is a relatively low percentage with respect to total Egyptian foundries using induction furnaces. Despite the known advantages of induction furnaces, most foundries fail to benefit from these advantages due to its high initial investment, use of dirty scrap, the absence of charge weighting/dosing and absence of molten chemical composition analysis during melting and refining stages. Usually workers depend on their experiences to estimate the chemical composition and the temperature of the melt.

5. Most foundries use cupola furnaces with the following characteristics:

   - Small size (2-4 ton/h productivity)
   - Cold blast
   - Absence of air cleaning system or low efficient system
   - Almost no shell water cooling
   - No control of blast flow rate
   - Used scrap is neither treated nor classified
   - No duplex[2] methods are used
   - The melt is tapped directly from the cupola every 20-30 min, without using receivers[3]. Receivers are very important for melt homogenizing, alloying, refining and production of relatively large size castings
   - Chemical analysis of the melt and temperature measurements are rarely used
   - Charging of the furnace is manual
   - Charging door are usually without gate
   - High losses
   - Low melt quality
   - No use of flue gases (600-800°C, 18% carbon monoxide) as energy source.

6. With respect to molding and core making, the survey has shown that:

   - About 80% of the foundries use green sand molding
   - Cores are rarely used because only simple flat casting and sanitary castings are produced.
   - Most of casting defects are due to the molding mixtures used and mold making technology applied.
   - Molding mixtures are prepared manually or using simple and low efficient equipment
   - Low quality sands and binders are used (sometimes non-foundry sands are used)
   - No quality control measurements are performed for the molding mixtures.

[2] Using two different melting units together, usually cupola and induction furnaces such that scrap is heated first in the cupola furnace. Most impurities, with melting points lower than that of the main metal, are emitted in the form of flue gases, before the charge is transferred to the induction furnace, thus improving the castings quality.
[3] A receiver is a closed vessel, lined with thermal bricks, used to empty the whole furnace once.

7. Shake-out and Fettling

   - Most shakeout operations are manual with no air cleaning system.
   - Casting surfaces are cleaned manually using primitive methods such as wire brushes with no protective measures for workers from dusts.

8. Heat Treatment

   Heat treatment is rarely used in Shoubra El Kheima to relieve stresses or for any other purpose of phase transformation.

9. Casting Surface Protection

   Many foundries use painting for surface protection yet no galvanization is used for surface protection. Some foundries use enameling for casting protection.

10. According to the results of the survey, the total number of employees (engineers, assistants, workers and foremen) in Abu Zaabal foundries are 3500. Those expected to move to Abu Zaabal are 2000- 2500 representing 60% of the total employees. Assistants will probably be employed from Abu Zaabal districts and the engineers will not live in the site residential area.

Chapter 4
Assessment of Environmental Impacts

In chapter 4, the potential impacts of the project on natural and biological life, environmental quality as well as social and economic environment during construction and operation phases were investigated.

Impacts of Construction Phase:

- The following impacts were identified for the construction phase:
  - Negative impacts on water quality, air quality, agricultural land, flora, fauna and health, negative noise impacts and negative social impacts.
  - Positive impacts on employment opportunities.

- All negative impacts, except those on fauna and flora on-site, could be mitigated through imposing control measures on contractors of major construction works on the site. The fauna and flora of the site will totally be removed, however, none is a rare or valuable species.

Impacts of Operation Phase:

- The following impacts were identified for the operation phase:
  - Negative impacts on public sewer system, land quality, occupational health, negative noise impacts
  - Positive impacts on services and employment
  - Impacts on air quality are considered in details in chapter 6 since air quality is sensitive to relative distribution of foundries and has impacts on health and biological life.

- All negative impacts could be mitigated through implementing technological and management control measures in foundries and the centralization of a number of services.

The construction and operation phases of the proposed relocation could negatively impact the natural, social and economic systems of the area if appropriate mitigation measures are not implemented. Possible impacts are identified and assessed using a methodological approach in accordance with the legal requirements of the Environmental Law (Law 4/94).

After scoping a checklist of all environmental elements that are generally considered, the elements that are of highest priority and relevance to the project were identified. They can be classified as following:

1. Natural and Biological Environment
   - Landscape
   - Flora and Field Crops
   - Fauna and Domestic Animals
2. Environmental Quality
   - Water
   - Air
   - Land
   - Noise
3. Social and Economic Environment
   - Occupational Health
   - Public Health
   - Services
   - Direct Employment
   - Indirect Employment
   - Lifestyle Impacts
   - Industrial Development

As for the project activities, they can be basically divided into the relocation phase, which involves moving the industries from Shoubra El Kheima and the construction and operation phases of the relocated facilities in Abu Zaabal.

The matrix method is used for environmental evaluation, as it provides a way of relating the project's basic activities (shown in rows) with the environmental elements listed (shown in columns). The interaction between project activities and the environmental elements represents an impact, as shown in Table (4.1).

Environmental impacts were classified as follows:

- Reversible or irreversible.
- Direct or indirect.
- Local or regional.
- Short-term or long-term.
- Negative or positive.

Impacts of each phase, construction and operation, followed by the proposed mitigation measures will be discussed below.

Table (4.1) Matrix of Potential Project Impacts on Environmental Elements

	Environment							Social- Economical						
	Natural & Biological			Quality										
	Landscape	Flora& Crops	Fauna & Animals	Water	Air	**Land**	Noise	Occupational Health	Public Health	Services	Direct Employment	IndirectEmployment	Lifestyle Impacts	Industrial Development
Relocation Phase:														
Moving industries from Shoubra El kheima														
Construction Phase:														
Earth Works														
Infrastructure Works														
Laying of aphalt concrete roads														
Building of Services														
Operation Phase:														
Foundry Operation														
Traffic on Roads														
Residential Areas														
Green buffers and green areas														

4.1 Impacts during the Construction Phase

Construction site operations can be the source of a variety of environmental problems. Some of these, such as noise, dust and fumes, are temporary, though causing serious nuisances. Others, such as spillage, which may contaminate soil or reach groundwater, can have more long-term effects. The mitigation of these problems generally lies in improving construction site management and in adopting environmentally sound practices.

4.1.1 Water Quality

Irreversible Long-term Regional Direct Negative Impact

The areas where water is susceptible to pollution are in the two depression areas that are in the northern part of the site as water is seeping into these depressions through fissures and cracks in the soil structure. Another active quarry exists in the central west. These areas are potential routes for underground water contamination unless properly lined with a layer of impervious material (e.g. silty clay) before earth filling and land leveling.

4.1.2 Air and Land Quality

Reversible Short-term Local Direct Negative Impact

The construction activities from site preparation, building of structural work to finishing works cause the emission of considerable amounts of dust, fumes, aerosols and possible hazardous volatile organic compounds. Moreover, dust particles may deposit on the soil causing contamination.

4.1.3 Noise

Reversible Short-term Local Direct Negative Impact

Noise and vibrations will arise from various sources: vehicles, equipment and machinery for handling and transport of material. The noise pollution during this phase is short term and reversible.

4.1.4 Biological Life

This phase will have strong impacts on the wild life and the biological system of the area. It will lead to the destruction of the biological system in the relocation site. The impacts can be summarized as follows:

a. Impacts on Agricultural Land

No Impact

The nearest cultivated land is about 2 km away and thus will not be affected in this phase since it is far enough from the site.

b. Impacts on Flora and Fauna

ON SITE: Irreversible Long-term Local Direct Negative Impact
OFF SITE: Reversible Short-term Local Indirect Negative Impact

- All the wild plants on site will be removed or buried during the leveling and infrastructure works.

- Wild plants off-site will not be affected by low sulfur dioxide emissions from motors, since these plants could tolerate high pollution levels.

- Some of the animals, such as rats and rodents will be exterminated during the leveling and infrastructure works. Generally, there is no threatened or rare species in the site.

- Some animals of the relocated area will migrate to the neighboring area during construction.

- Some animal species in the neighborhood could be affected e.g. birds, during construction as result of noise and dust.

4.1.5 Employment Opportunities

Irreversible Short-term Local & Regional Direct Positive Impact

During construction, the effect on employment will depend on the intended plan of the governorate for site development. If the governorate intends to be responsible for the overall construction process; land preparation, infrastructure and superstructure, then the job will be contracted to major contractors. In this case, minimal local employment will be used.

However, it is more likely that the goveronate will be solely responsible for site leveling, building of infrastructure (water, sanitary, electricity, natural gas and road network). The industrial and residential facilities will be built in phases in accordance to institutional plans for relocation to the site. Thus, the construction stage will generate a high demand for temporary employment. It is likely that the demand for labor will exceed the labor supply available in Abu Zaabal and will encourage migration of temporary workers from neighboring districts to the site.

4.1.6 Health and Safety

Reversible Short-term Local Direct Negative Impact

Potential impacts during the construction phase are typically those related to health and safety, including vehicular accidents due to the increase in traffic congestion in work areas, respiratory ailments due to fugitive dusts and/or the exhausts of heavy construction equipment. In addition, a major health and safety issue may arise in the neighboring residential and agricultural areas due to the migration and escape of the rodents, rats and pests currently resident in the site as soon as site leveling and earthmoving operations commence.

4.1.7 Social Impacts

Reversible Short-term Local Direct Negative Impact

Construction near a residential area is essentially an intrusion in the day-to-day life of the community. Although activities specifically related to the act of construction may be tolerated as merely temporary inconveniences, inappropriate or ill-advised behavior of construction crews that are temporarily settling on site is not accepted as easily. Inappropriate behavior that may be considered innocent by the construction crew can be viewed more seriously by individuals and groups within the community. Examples of this behavior include subjection of citizens to inappropriate visual and verbal acts as well as the existence of the poor and primitive settlements of laborers that lack basic sanitary services.

4.2 Mitigation Measures for the Construction Phase

Construction activities have significant impacts on the environment, including degradation of wildlife habitats, erosion and/or compaction of soils, dust and noise pollution, in addition to adverse health and social impacts. The following mitigation measures and pollution prevention techniques can help reduce construction effects.

The following measures should be reflected in the contractual agreements with the major construction companies involved in the site development works. They would be properly monitored by the promoter of the project (the Governor of Qualubiya).

4.2.1 Water Quality

The depression areas that are the potential routes for underground water contamination should be properly lined with a layer of impervious material (e.g. silty clay) before earth filling and land leveling.

4.2.2 Air and Land Quality

- Keep the soil surface humid, for example, through water spraying to keep a low level of dust during earthmoving.

- Set proper material and storage areas to reduce chance of material contamination or exposure.

- Provide secondary containment in equipment fueling areas.

- Minimize the introduction of hazardous constituents to soils, groundwater and air before, during and after construction.

- Prevent noxious or hazardous air emissions, including volatile organic compounds from being vented or released to the air.

- Dispose construction wastes in a manner that will minimize the potential for release of contaminants to the environment. Solid inert waste can be used as a bedding for the dumpsite.

4.2.3 Health and Safety

- Set a plan to exterminate rodents, pests and rats that resident on site before starting any earthworks so as to prevent their migration to the neighboring residential areas.

- Identify the safest and least populated routes of travel from transportation of wastes from the facility by trucks.

- Transport raw material and wastes in a safe contained manner, that is, properly covered and secured.

4.2.4 Social Measures

- Locate the shelters of the construction crew involved in the major preparation works away from the existing residential areas, preferably locate them west of the railway.

- Provide the laborers with proper secured sanitation areas.

4.2.5 Noise Control

The following measures should be taken:
- Prohibiting construction works at night.
- Use of proper equipment

4.3 Impacts during the Operation Phase

4.3.1 Water Quality

Reversible, Long-term, Regional, Indirect Negative Impact

- There are no surface water bodies present within or next to the designated site.

- Moreover, the ground water table in the site is deeper than 15 m and is protected from surface infiltration by a thick impermeable layer of basalt. Thus, the operation of the industries in the site will have no impact on surface or underground water quality even in case of spillage or leakage.

- Industrial wastewater resulting from foundry operations is characterized by being acidic (low pH), contains high COD, oil and grease, heavy metals as well as settlable matter. If this wastewater is discharged directly into the public sewage network, it will impose a pollution load on the network higher than that allowed by Law 93/1962. Moreover, the accumulated load will pose a burden on the public sewage treatment plant and is likely to persist in its effluents to regional water bodies and the sludge resulting from the treatment process.

4.3.2 Land Quality

Irreversible, Long-term, Local, Direct Negative Impact

a. Effect of Raw Materials

Sand, coke and bentonite are the raw materials that may affect the land quality of the site. The storage of these materials in open areas in the foundries will require large spaces, thus affecting foundry activities. Moreover, air borne sand particles will be carried by the wind to settle on neighboring areas and will be a nuisance to the area residents. Because of its lightweight and small size, bulk bentonite delivered to the facilities is a major source of ground level pollution.

b. Solid Waste

The solid wastes generated from foundries activities are slag, waste sand and dust.

Slag

Slag, the reduced metal bearing charge by-product, is produced from melting furnaces. Depending on the type of foundry, this slag may or may not contain hazardous components. Slag produced in iron foundries, copper and aluminum foundries does not represent a problem since it does not contain hazardous materials. Tables (4.2, 4.3) give the constituents of slag from iron and copper foundries respectively.

Table (4.2) Constituents of Slag Resulting from Iron Foundries

Component	Weight Percent	
	Induction Furnace	Cupola
SiO_2	-----	25-60
Mn/MnO	7	1-5
FeO/ Fe_2O_3	3	0.5-10
Al_2O_3	6	5-20
CaO	2	20-50
MgO	9	1-5
CaF_2	1	-----
$CaSO_4$ or CaS_2	0.1	0.05-1
P_2O_5	0.1	0.1-1

Table (4.3) Constituents of Slag Resulting from Copper Foundries

Component	Weight Percent
SiO_2	20-50
Mn/MnO	20-30
Al_2O_3	10-15
Na_2O	5-10
CuO	2

Slag resulting from lead smelters contains lead, which is a hazardous waste according to the Basel Convention. However, lead percentage in slag is less than 2%, thus considered non-hazardous according to the EPA standards. Table (4.4) gives the composition of slag from lead smelters.

Table (4.4) Constituents of Slag from Lead Smelters

Component	Weight Percent
Total Sulfur	0.75
Total Lead	1.054
Total Iron	38.301

Source: Egyptian Geological Survey and Mining Authority Laboratory Sectors, June 1998

The amount of produced slag from cupola furnaces can be reduced by using coke of low sulfur content or using other clean fuels. Handling of slag is discussed later in the mitigation measures (section 4.4).

<u>Waste Sand</u>

Large amounts of waste sand are produced from the foundries. Table (4.5) gives the daily amount of waste sand.

Table (4.5) Daily Amounts of Waste Sand*

Secondary Smelter	Amounts of Sand in ton/day
Iron Foundries	390
Copper and aluminium foundries	180

* Based on data from chapter 3

4.3.3 Air Quality

Foundry and smelter operation emit a considerable amount of air pollutants that may significantly reduce the quality of air and affect the public health and biological life in the area. However, air quality unlike water and land quality, will be affected by many design variables such as the relative location of industries in the site, their working conditions and melting technologies. Estimation of the major air pollutants concentrations required extensive modelling and consideration of alternate land use distribution and thus will be discussed in detail in Chapter 6.

4.3.4 Noise

Reversible Long to short term Local & Regional Direct Negative Impact

Noise will mainly arise from foundry and smelter operation and from the traffic associated with the urban and industrial development of the area. Noise from foundries operation will arise during:

- receiving and storage of raw materials
- battery processing in lead smelters
- charging of furnaces in all foundries
- sand processing and handling
- shake-out stage
- product shipment

The industrial development will result in an increase in traffic volume, especially heavy traffic such as trucks and buses, increasing neighborhood noise levels. Transportation calculations, shown in chapter 7, had estimated a peak hour traffic flow of 100 vehicle/hour.

Noise pollution effects on human beings are classified as auditory and non-auditory effects. Auditory effects are unlikely to occur in this case. Non auditory effects may cause:

- Sleep intervention
- Recreational impediment
- Annoyance
- Loss of working efficiency

Law 4/94 specifies maximum permissible limits for noise intensity in different zones. The site is mainly divided into a residential zone to accommodate the workers and their families and an industrial zone. Work will be prohibited between 10 p.m. and 7 a.m. Noise control measures should be considered if the following limits are exceeded.

Table (4.6) Maximum Permissible Limits for Noise Intensity

Type of Zone	**Permissible Limits for Noise Intensity Decibel**			
	Day*		**Evening****	
	from	**To**	**From**	**to**
Residential areas including some workshops or commercial businesses or on public roads	50	60	45	55
Industrial areas (Heavy Industries)	60	70	55	65

* from 7 a.m. to 6 p.m.
** from 6 p.m. to 10 p.m.

4.3.5 Occupational Health

Reversible/Irreversible Long- to short term/ Local Negative Impact

a. *Noise*

Workers are exposed to high noise levels during ramming (in case of foundries), near the compressors, air blowers, during furnace charging and in the battery processing area in case of secondary lead smelters.

b. *Emissions*

In the foundries, silica and metal dust are emitted during material handling and finishing processes in the following areas:

- molding and core making unit especially during mixing and ramming.
- shaking-out unit
- Cleaning and fittling unit

Moreover, traces of organic fumes such as formaldehyde may evolve during the metal pouring.
In lead smelters, lead oxide dust and fumes are emitted during furnaces charging, lead taping and battery breaking. Dust is also emitted in the battery breaking area, materials storage and handling area (including, but not limited to areas in which slag and flue dust are stored) and smelting furnaces area.

c. Heat Stress

Workers are exposed to heat stress at the melting furnaces especially during charging and refining areas.

4.3.6 Social Impacts

The social cultural settings strongly interact with policy choices. These interactions have three implications. First, evaluation of a project's effect may be biased unless social cultural settings are correctly accounted for. Second, with sufficient knowledge, the choice of projects might be tailored to the social cultural setting. Third, local groups or communities might also draw on this knowledge to change aspects of their social cultural setting.

In the context of interactions of policy choices and sociocultural settings, three areas are to be considered. First, sociocultural feasibility in terms of the compatibility of the project with the sociocultural environment in which it is to be introduced. Second, spread effects in terms of the likelihood that the new practices introduced will be diffused among the greatest number of target groups or population. Third, social consequences and benefit incidence in terms of the benefits and burdens among different group within the initial project and beyond it.

a. Relocation of Workers

The relocation of workers is not an objective of the project. However, some of those will relocate with their families in the development site. The basic premise is that people do not relocate unless they perceive this action to represent in one way or another a better alternative than other available options. In any case, the relocation of workers and their families is not an easy operation. The available data is not sufficient to predict the interaction of the concerned communities with the issue of relocation. A number of questions need to be answered to give an indication of the expected extent of relocation:

1- How do the workers and their families make their choices, who will be willing and who will refuse? What are the variables that will affect their choices? Is it the bigger house, the better infrastructure, the proximity to work place or the private home for a newly established family? Or might the preferences be staying at the place and with the people they are used to, whatever the conditions are?

2- Are the workers, currently living outside Shoubra El Kheima, more likely to move or not to move to Abu Zaabal? And how far do their present place of residence affect their choice to move? What might affect their choices in this concern?

3- What might be the related factors or variables in such a choice? Is it the level of income, education, age, type of family or present housing conditions?

4- Do they perceive the relocation as a means of upgrading? And for whom might relocating be an upgrading? Is it again related to some factors like being newly married in an extended family or intending to marry and needing a shelter?

5- For those workers that owners need to keep, what might be the incentives to motivate and encourage them to move? And what might be the best incentives? How far does this affect the production economics?

6- The residential area is designed such that there are 1392 apartments to accommodate 5568 inhabitants (4 /family). Based on the survey conducted in Shoubra El Kheima, the total number of personnel working in the foundries is estimated to be 3500, 60% of which are workers. It is clear that the number of apartments is less than the number of workers that should occupy them. What is the number of workers more likely to be willing to move versus the capability and capacity, of both the project and the Abu Zaabal area, to receive these numbers of new comers? What might be case if more than the estimated number of workers will be willing to move? What might be then the way to set priority target groups and what are the considered criteria in this concern?

7. Finally, how far do previous experiences in relocating workers and their families to new communities relate to the case in hand? Whether it was successful or not, what might be the causes in both cases?

These questions, and many others, need to be answered carefully to ensure the overall success of the project. There is no doubt that these issues will directly influence the economic performance of the project and therefore should be considered. To obtain adequate information to rely on in taking appropriate decisions and measures, a social study, outside he scope of this report, should be conducted to investigate these questions and draw patterns of expected preferences, perceptions and attitudes of the workers towards them.

b. Employment

Irreversible, Long-term, Local & Regional, Direct & Indirect Positive Impact

The relocation plan will not affect the regional capacity of employment since the same number of workers will be employed in the metal industries within the Qalubiya governorate. Only the geographical distribution of the employees will change depending on the number of workers that are willing to move their residence from Shoubra El Kheima to Abu Zaabal and the ones that will still live in Shoubra El Kheima but are willing to work in Abu Zaabal. The portion of work force that does not intend to relocate will be made up for from the labor force present near the designated site of Abu Zaabal.

However, employment creation in Abu Zaabal is not totally dependent on the uncertain relocation of the industrial work force. The development of services in the new industrial site will generate direct employment opportunities for local population of Abu Zaabal. The main services that will create employment are the industrial wastewater treatment plant, the solid waste transfer station, central stores, environmental management unit and other community services that will be located in the site. Nevertheless, the information available is not sufficient to estimate the potential employment of the local community members. Generally, the higher level of economic activity in the relocation area will create indirect employment opportunities in services and trade as well as backward and forward linked activities.

Three. Impact on Services

Irreversible Long-term Local Direct & Indirect Positive/ Negative Impact

The site should be equipped with a new efficient infrastructure for water, wastewater, electricity and telephone. If it is not designed or built properly, the planned development will act as a burden on the existing poor infrastructure and this will have negative impacts on the area as a whole. On the other hand, the provision of required infrastructure would have a spillover positive impact on the surrounding community. The infrastructure requirements will be discussed in chapter 7.

Therefore, the existing community of Abu Zaabal will benefit from the development of the neighboring site in terms of benefiting from the services and opportunities associated with the site development. They can also benefit from the social services and recreation area that will be built in the neighboring site (see chapter 7).

d. Lifestyle Impacts

Irreversible Long-term Local Direct Negative Impact

The adjacency of proposed industrial estate to the existing residential area of Masaken Abu Zaabal represents a major intrusion to the life style of the current residents. Although, the workers along with their life styles and values, the community of Abu Zaabal seems not to be totally different from those incoming residents since a number of them are likely to be employed in the neighboring industries.

4.3.7 Industrial Development

Irreversible Long-term National Direct Positive Impact

Industrial development in Egypt is one of the major goals of the government. The selected location is part of the industrial district belonging to the Qalubiya governorate as designated by the planning sector of the governorate. Industrial development (using modern technology) in this region contributes to the industrial development of Egypt. The concentration of foundries in the area will create opportunities for training, quality upgrading of inputs as well as outputs through more open competition.

4.4 Mitigation Measures for Operation Phase

Generally speaking, mitigation can be achieved through the following means:

- Reducing or eliminating emissions through process changes, substitution of materials, or other modifications.
- Collecting, capturing and/or treating pollutants
- Designing (and/or equipment modification) tighter control on work practice, operational standards, etc.
- Centralization of services to serve the foundry operations.

4.4.1 Mitigation Measures for Water Quality

In order to control high pollution discharge to the network, a separate private network is recommended to collect the industrial wastewater and treat it in a central wastewater treatment plant. A central treatment of wastewater, before discharging to the public sewers network, is economically efficient when compared to isolated treatment at the individual plant level. It also allows better assurance of the continuous operation of the plant, and the adequate disposal of sludge.

The treatment process could be tailored to the common characteristics shared by industrial wastewater that will result from factory operations. Some compounds should be separated at the plant level to prevent clogging or corrosion of the private sewer system.

- Oil and grease should be separated from wastewater using an oil separator and may be collected from the foundries.

- Neither acids used in pickling operations nor cyanide should not be discharged with the wastewater. They should be collected separately for collection and treatment, or regeneration in case of acids.

- Highly settlable solids should not be allowed in the private sewer systems because they may cause clogging. The foundry collection tank should be designed in a way that allows for a sufficient residence time for solids settling. The collection tanks should be periodically cleaned to remove the settlable solids.

The wastewater treatment plant will consist of an equalization tank/pond to equalize shock loads, neutralization tank, settler (using calcium carbonate) and heavy metal removing process. De-watering of sludge produced from the treatment plant should reduce the land needed for its drying before being disposed of in a proper disposal site. The treated water may be used in irrigation of neighboring tree lines. Each foundry will pay treatment expenses according to its production capacity.

4.4.2 Mitigation Measures for Land Quality

a. *Central Storage of Raw Material*

Central stores for material such as sand, coke and bentonite, the inadequate storage of which is a serious source of pollution, provide the least cost option for environmental control. Central stores for input materials will substantially reduce ground pollution generated from the industrial facilities. However, the accumulation of dust in the industrial areas cannot be totally avoided. In order to minimize its secondary effects, paving and housekeeping (cleaning, water spraying and adequate storage of raw material) will be enforced.

It should be noted that these central stores could indirectly reduce other environmental effects:

- The throughput of sand is substantially increased in case foundries use off-specification sand.
- Off-specification coke supplied to the foundries affects the quality of their products and decreases the life of the refractories of their furnaces.

b. *Industrial Solid Waste Management – Central Transfer Station*

Industrial waste mainly consists of waste sand, slag and dust. All the waste collected from foundries should be transported to a central transfer station in the site. From there, each type of waste will be sold as a byproduct to the relevant industry or disposed of properly.

Waste sand could be reused in the base layers of road pavements or as a separator soil layer in the neighboring dumpsite. As for the slag, it can be reused in:

- Cement manufacturing.
- As an aggregate in road construction and reinforced concrete and building bricks. It could also be used to substitute railway track basalt or instead of some sand and gravel of water purification filters.
- Manufacture of lightweight brick or in precast concrete panels, pre-cast walls, beams, and slabs.

c. *Measures to Minimize Solid Waste*

- Only foundry sands should be used to minimize waste sand
- Proper handling, transportation and storage of materials

4.4.3 Noise Control

Reduction of noise at source or insertion of a barrier between the noise source and the receptor can achieve noise control. In this case, acoustic seals around the foundries could reduce indoor and outdoor noise pollution. Moreover, green buffer and the railway would act as barrier and increase the distance between the industrial zone and neighboring residential areas.

Generally speaking, noise control measures are regulatory including land use zoning and environmental quality standards. These measures can be classified as follows:

a. Measures Already Considered in the Urban and Operation Plan

- The railway and a buffer of trees that will be planted next to the railway will act as a buffer zone between the industrial source and the receptor residential area.
- Prohibition of operation at the night shift will considerably reduce the noise level from 10:00 p.m. until 7:00 a.m.

b. Measures to be Applied if Needed

- Construction of noise barriers or devices
- Noise insulation of public use buildings such as schools and hospitals

4.4.4 Measures for Improving Working Conditions

a. Compulsory Measures

- Using mechanical shakeout of the castings, with air cleaning system, instead of manual shakeout.
- The installation for ladles drying and preheating should be equipped with flue gas suction system and suitable stack
- Provide workers with protective equipment such as masks, ear protection, etc.

b. Foundries Should be Encouraged to:

- In case of floor molding[4], ramming should be pneumatic
- Use molding machines, permanent mold casting, centrifugal casting and others
- Apply a suitable ventilation system in underground tunnels

4.4.5 Mitigation Measures for Social Impacts

The urban plan takes into consideration that the new residential area be located next to the current residents of Abu Zaabal and that the industries' pollution and culture are separated from the residential areas by the rail tracks, a road and an added green buffer. Locating the two communities next to each other

4 molding performed in pits on the floor, ramming is sometimes performed manually by mixing sand with water and bentonite, a very tedious operation.

will allow for sharing of social services associated with each community and would decrease the time period needed for the assimilation of new comers.

4.3 Impacts during the Operation Phase

4.3.1 Water Quality
Reversible, Long-term, Regional, Indirect Negative Impact

- There are no surface water bodies present within or next to the designated site.

- Moreover, the ground water table in the site is deeper than 15 m and is protected from surface infiltration by a thick impermeable layer of basalt. Thus, the operation of the industries in the site will have no impact on surface or underground water quality even in case of spillage or leakage.

- Industrial wastewater resulting from foundry operations is characterized by being acidic (low pH), contains high COD, oil and grease, heavy metals as well as settlable matter. If this wastewater is discharged directly into the public sewage network, it will impose a pollution load on the network higher than that allowed by Law 93/1962. Moreover, the accumulated load will pose a burden on the public sewage treatment plant and is likely to persist in its effluents to regional water bodies and the sludge resulting from the treatment process.

4.3.2 Land Quality
Irreversible, Long-term, Local, Direct Negative Impact

a. Effect of Raw Materials

Sand, coke and bentonite are the raw materials that may affect the land quality of the site. The storage of these materials in open areas in the foundries will require large spaces, thus affecting foundry activities. Moreover, air borne sand particles will be carried by the wind to settle on neighboring areas and will be a nuisance to the area residents. Because of its lightweight and small size, bulk bentonite delivered to the facilities is a major source of ground level pollution.

b. Solid Waste

The solid wastes generated from foundries activities are slag, waste sand and dust.

Slag

Slag, the reduced metal bearing charge by-product, is produced from melting furnaces. Depending on the type of foundry, this slag may or may not contain hazardous components. Slag produced in iron foundries, copper and aluminum foundries does not represent a problem since it does not contain hazardous materials. Tables (4.2, 4.3) give the constituents of slag from iron and copper foundries respectively.

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Component	Weight Percent	
	Induction Furnace	Cupola
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CaO	2	20-50
MgO	9	1-5
CaF_2	1	-----
$CaSO_4$ or CaS_2	0.1	0.05-1
P_2O_5	0.1	0.1-1

Table (4.3) Constituents of Slag Resulting from Copper Foundries

Component	Weight Percent
SiO_2	20-50
Mn/MnO	20-30
Al_2O_3	10-15
Na_2O	5-10
CuO	2

Slag resulting from lead smelters contains lead, which is a hazardous waste according to the Basel Convention. However, lead percentage in slag is less than 2%, thus considered non-hazardous according to the EPA standards. Table (4.4) gives the composition of slag from lead smelters.

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Component	Weight Percent
Total Sulfur	0.75
Total Lead	1.054
Total Iron	38.301

Source: Egyptian Geological Survey and Mining Authority Laboratory Sectors, June 1998

The amount of produced slag from cupola furnaces can be reduced by using coke of low sulfur content or using other clean fuels. Handling of slag is discussed later in the mitigation measures (section 4.4).

Waste Sand

Large amounts of waste sand are produced from the foundries. Table (4.5) gives the daily amount of waste sand.

Table (4.5) Daily Amounts of Waste Sand*

Secondary Smelter	Amounts of Sand in ton/day
Iron Foundries	390
Copper and aluminium foundries	180

* Based on data from chapter 3

4.3.3 Air Quality

Foundry and smelter operation emit a considerable amount of air pollutants that may significantly reduce the quality of air and affect the public health and biological life in the area. However, air quality unlike water and land quality, will be affected by many design variables such as the relative location of industries in the site, their working conditions and melting technologies. Estimation of the major air pollutants concentrations required extensive modelling and consideration of alternate land use distribution and thus will be discussed in detail in Chapter 6.

4.3.4 Noise

Reversible Long to short term Local & Regional Direct Negative Impact

Noise will mainly arise from foundry and smelter operation and from the traffic associated with the urban and industrial development of the area. Noise from foundries operation will arise during:

- receiving and storage of raw materials
- battery processing in lead smelters
- charging of furnaces in all foundries
- sand processing and handling
- shake-out stage
- product shipment

The industrial development will result in an increase in traffic volume, especially heavy traffic such as trucks and buses, increasing neighborhood noise levels. Transportation calculations, shown in chapter 7, had estimated a peak hour traffic flow of 100 vehicle/hour.

Noise pollution effects on human beings are classified as auditory and non-auditory effects. Auditory effects are unlikely to occur in this case. Non auditory effects may cause:

- Sleep intervention
- Recreational impediment
- Annoyance
- Loss of working efficiency

Law 4/94 specifies maximum permissible limits for noise intensity in different zones. The site is mainly divided into a residential zone to accommodate the workers and their families and an industrial zone. Work will be prohibited between 10 p.m. and 7 a.m. Noise control measures should be considered if the following limits are exceeded.

Table (4.6) Maximum Permissible Limits for Noise Intensity

Type of Zone	Permissible Limits for Noise Intensity Decibel			
	Day*		Evening**	
	from	To	From	to
Residential areas including some workshops or commercial businesses or on public roads	50	60	45	55
Industrial areas (Heavy Industries)	60	70	55	65

* from 7 a.m. to 6 p.m.
** from 6 p.m. to 10 p.m.

4.3.5 Occupational Health

Reversible/Irreversible Long- to short term/ Local Negative Impact

a. Noise

Workers are exposed to high noise levels during ramming (in case of foundries), near the compressors, air blowers, during furnace charging and in the battery processing area in case of secondary lead smelters.

b. Emissions

In the foundries, silica and metal dust are emitted during material handling and finishing processes in the following areas:

- molding and core making unit especially during mixing and ramming.
- shaking-out unit
- Cleaning and fittling unit

Moreover, traces of organic fumes such as formaldehyde may evolve during the metal pouring.
In lead smelters, lead oxide dust and fumes are emitted during furnaces charging, lead taping and battery breaking. Dust is also emitted in the battery breaking area, materials storage and handling area (including, but not limited to areas in which slag and flue dust are stored) and smelting furnaces area.

c. Heat Stress

Workers are exposed to heat stress at the melting furnaces especially during charging and refining areas.

4.3.6 Social Impacts

The social cultural settings strongly interact with policy choices. These interactions have three implications. First, evaluation of a project's effect may be biased unless social cultural settings are correctly accounted for. Second, with sufficient knowledge, the choice of projects might be tailored to the social cultural setting. Third, local groups or communities might also draw on this knowledge to change aspects of their social cultural setting.

In the context of interactions of policy choices and sociocultural settings, three areas are to be considered. First, sociocultural feasibility in terms of the compatibility of the project with the sociocultural environment in which it is to be introduced. Second, spread effects in terms of the likelihood that the new practices introduced will be diffused among the greatest number of target groups or population. Third, social consequences and benefit incidence in terms of the benefits and burdens among different group within the initial project and beyond it.

a. Relocation of Workers

The relocation of workers is not an objective of the project. However, some of those will relocate with their families in the development site. The basic premise is that people do not relocate unless they perceive this action to represent in one way or another a better alternative than other available options. In any case, the relocation of workers and their families is not an easy operation. The available data is not sufficient to predict the interaction of the concerned communities with the issue of relocation. A number of questions need to be answered to give an indication of the expected extent of relocation:

1- How do the workers and their families make their choices, who will be willing and who will refuse? What are the variables that will affect their choices? Is it the bigger house, the better infrastructure, the proximity to work place or the private home for a newly established family? Or might the preferences be staying at the place and with the people they are used to, whatever the conditions are?

2- Are the workers, currently living outside Shoubra El Kheima, more likely to move or not to move to Abu Zaabal? And how far do their present place of residence affect their choice to move? What might affect their choices in this concern?

3- What might be the related factors or variables in such a choice? Is it the level of income, education, age, type of family or present housing conditions?

4- Do they perceive the relocation as a means of upgrading? And for whom might relocating be an upgrading? Is it again related to some factors like being newly married in an extended family or intending to marry and needing a shelter?

5- For those workers that owners need to keep, what might be the incentives to motivate and encourage them to move? And what might be the best incentives? How far does this affect the production economics?

6- The residential area is designed such that there are 1392 apartments to accommodate 5568 inhabitants (4 /family). Based on the survey conducted in Shoubra El Kheima, the total number of personnel working in the foundries is estimated to be 3500, 60% of which are workers. It is clear that the number of apartments is less than the number of workers that should occupy them. What is the number of workers more likely to be willing to move versus the capability and capacity, of both the project and the Abu Zaabal area, to receive these numbers of new comers? What might be case if more than the estimated number of workers will be willing to move? What might be then the way to set priority target groups and what are the considered criteria in this concern?

7. Finally, how far do previous experiences in relocating workers and their families to new communities relate to the case in hand? Whether it was successful or not, what might be the causes in both cases?

These questions, and many others, need to be answered carefully to ensure the overall success of the project. There is no doubt that these issues will directly influence the economic performance of the project and therefore should be considered. To obtain adequate information to rely on in taking appropriate decisions and measures, a social study, outside he scope of this report, should be conducted to investigate these questions and draw patterns of expected preferences, perceptions and attitudes of the workers towards them.

b. Employment

Irreversible, Long-term, Local & Regional, Direct & Indirect Positive Impact

The relocation plan will not affect the regional capacity of employment since the same number of workers will be employed in the metal industries within the Qalubiya governorate. Only the geographical distribution of the employees will change depending on the number of workers that are willing to move their residence from Shoubra El Kheima to Abu Zaabal and the ones that will still live in Shoubra El Kheima but are willing to work in Abu Zaabal. The portion of work force that does not intend to relocate will be made up for from the labor force present near the designated site of Abu Zaabal.

However, employment creation in Abu Zaabal is not totally dependent on the uncertain relocation of the industrial work force. The development of services in the new industrial site will generate direct employment opportunities for local population of Abu Zaabal. The main services that will create employment are the industrial wastewater treatment plant, the solid waste transfer station, central stores, environmental management unit and other community services that will be located in the site. Nevertheless, the information available is not sufficient to estimate the potential employment of the local community members. Generally, the higher level of economic activity in the relocation area will create indirect employment opportunities in services and trade as well as backward and forward linked activities.

Three. Impact on Services

Irreversible Long-term Local Direct & Indirect Positive/ Negative Impact

The site should be equipped with a new efficient infrastructure for water, wastewater, electricity and telephone. If it is not designed or built properly, the planned development will act as a burden on the existing poor infrastructure and this will have negative impacts on the area as a whole. On the other hand, the provision of required infrastructure would have a spillover positive impact on the surrounding community. The infrastructure requirements will be discussed in chapter 7.

Therefore, the existing community of Abu Zaabal will benefit from the development of the neighboring site in terms of benefiting from the services and opportunities associated with the site development. They can also benefit from the social services and recreation area that will be built in the neighboring site (see chapter 7).

d. Lifestyle Impacts

Irreversible Long-term Local Direct Negative Impact

The adjacency of proposed industrial estate to the existing residential area of Masaken Abu Zaabal represents a major intrusion to the life style of the current residents. Although, the workers along with their life styles and values, the community of Abu Zaabal seems not to be totally different from those incoming residents since a number of them are likely to be employed in the neighboring industries.

4.3.7 Industrial Development

Irreversible Long-term National Direct Positive Impact

Industrial development in Egypt is one of the major goals of the government. The selected location is part of the industrial district belonging to the Qalubiya governorate as designated by the planning sector of the governorate. Industrial development (using modern technology) in this region contributes to the industrial development of Egypt. The concentration of foundries in the area will create opportunities for training, quality upgrading of inputs as well as outputs through more open competition.

4.4 Mitigation Measures for Operation Phase

Generally speaking, mitigation can be achieved through the following means:

- Reducing or eliminating emissions through process changes, substitution of materials, or other modifications.
- Collecting, capturing and/or treating pollutants
- Designing (and/or equipment modification) tighter control on work practice, operational standards, etc.
- Centralization of services to serve the foundry operations.

4.4.1 Mitigation Measures for Water Quality

In order to control high pollution discharge to the network, a separate private network is recommended to collect the industrial wastewater and treat it in a central wastewater treatment plant. A central treatment of wastewater, before discharging to the public sewers network, is economically efficient when compared to isolated treatment at the individual plant level. It also allows better assurance of the continuous operation of the plant, and the adequate disposal of sludge.

The treatment process could be tailored to the common characteristics shared by industrial wastewater that will result from factory operations. Some compounds should be separated at the plant level to prevent clogging or corrosion of the private sewer system.

- Oil and grease should be separated from wastewater using an oil separator and may be collected from the foundries.

- Neither acids used in pickling operations nor cyanide should not be discharged with the wastewater. They should be collected separately for collection and treatment, or regeneration in case of acids.

- Highly settlable solids should not be allowed in the private sewer systems because they may cause clogging. The foundry collection tank should be designed in a way that allows for a sufficient residence time for solids settling. The collection tanks should be periodically cleaned to remove the settlable solids.

The wastewater treatment plant will consist of an equalization tank/pond to equalize shock loads, neutralization tank, settler (using calcium carbonate) and heavy metal removing process. De-watering of sludge produced from the treatment plant should reduce the land needed for its drying before being disposed of in a proper disposal site. The treated water may be used in irrigation of neighboring tree lines. Each foundry will pay treatment expenses according to its production capacity.

4.4.2 Mitigation Measures for Land Quality

a. Central Storage of Raw Material

Central stores for material such as sand, coke and bentonite, the inadequate storage of which is a serious source of pollution, provide the least cost option for environmental control. Central stores for input materials will substantially reduce ground pollution generated from the industrial facilities. However, the accumulation of dust in the industrial areas cannot be totally avoided. In order to minimize its secondary effects, paving and housekeeping (cleaning, water spraying and adequate storage of raw material) will be enforced.

It should be noted that these central stores could indirectly reduce other environmental effects:

- The throughput of sand is substantially increased in case foundries use off-specification sand.
- Off-specification coke supplied to the foundries affects the quality of their products and decreases the life of the refractories of their furnaces.

b. Industrial Solid Waste Management – Central Transfer Station

Industrial waste mainly consists of waste sand, slag and dust. All the waste collected from foundries should be transported to a central transfer station in the site. From there, each type of waste will be sold as a byproduct to the relevant industry or disposed of properly.

Waste sand could be reused in the base layers of road pavements or as a separator soil layer in the neighboring dumpsite. As for the slag, it can be reused in:

- Cement manufacturing.
- As an aggregate in road construction and reinforced concrete and building bricks. It could also be used to substitute railway track basalt or instead of some sand and gravel of water purification filters.
- Manufacture of lightweight brick or in precast concrete panels, pre-cast walls, beams, and slabs.

c. Measures to Minimize Solid Waste

- Only foundry sands should be used to minimize waste sand
- Proper handling, transportation and storage of materials

4.4.3 Noise Control

Reduction of noise at source or insertion of a barrier between the noise source and the receptor can achieve noise control. In this case, acoustic seals around the foundries could reduce indoor and outdoor noise pollution. Moreover, green buffer and the railway would act as barrier and increase the distance between the industrial zone and neighboring residential areas.

Generally speaking, noise control measures are regulatory including land use zoning and environmental quality standards. These measures can be classified as follows:

a. Measures Already Considered in the Urban and Operation Plan

- The railway and a buffer of trees that will be planted next to the railway will act as a buffer zone between the industrial source and the receptor residential area.
- Prohibition of operation at the night shift will considerably reduce the noise level from 10:00 p.m. until 7:00 a.m.

b. Measures to be Applied if Needed

- Construction of noise barriers or devices
- Noise insulation of public use buildings such as schools and hospitals

4.4.4 Measures for Improving Working Conditions

a. Compulsory Measures

- Using mechanical shakeout of the castings, with air cleaning system, instead of manual shakeout.
- The installation for ladles drying and preheating should be equipped with flue gas suction system and suitable stack
- Provide workers with protective equipment such as masks, ear protection, etc.

b. Foundries Should be Encouraged to:

- In case of floor molding[4], ramming should be pneumatic
- Use molding machines, permanent mold casting, centrifugal casting and others
- Apply a suitable ventilation system in underground tunnels

4.4.5 Mitigation Measures for Social Impacts

The urban plan takes into consideration that the new residential area be located next to the current residents of Abu Zaabal and that the industries' pollution and culture are separated from the residential areas by the rail tracks, a road and an added green buffer. Locating the two communities next to each other

[4] molding performed in pits on the floor, ramming is sometimes performed manually by mixing sand with water and bentonite, a very tedious operation.

will allow for sharing of social services associated with each community and would decrease the time period needed for the assimilation of new comers.

Chapter 5
Guidelines for Urban Planning and Land Use

Urban planning goals address the sustainability of the Abu Zaabal industrial estate by both providing an advanced internal structure and ensure its integration with the vicinity.

The internal structure ensures industrialist's needs, worker's livelihood and effective administration. The planning of the industrial sector facilitates the internal working of industrial process and provides for common industry specific services. The housing sector provides for the variety of residential demands and integrated services. The central administrative facilities ensure effective management and protection. And finally, the overall green strategy takes advantage of street structure to soften the visual impact of the industrial conglomeration.

The integration of the industrial estate with the vicinity is sought by ensuring a safe environment and the sharing of extensive services. The distribution of industrial plots distances disturbing industrial processes to provide, along with other restrictions, a safe environment. The provision of and sharing of social, cultural, educational and protective facilities shall help develop existing community.

The urban plan provides:

- Integration with existing community,
- Effective industrial organization,
- Strong administration,
- Safe residential environment,
- Extended central services, and
- Softened visual impact.

The Abu Zaabal industrial estate seeks to provide additional education, employment and services to the existing community.

The objective of this chapter is to convey the principles, process, and product of developing Abu Zaabal industrial site. The following sections will address relevant sector analysis, programs and plans, in preparation for an integrated physical, social and economical development of the site.

Appendix (I) includes a survey for previous successes in urban planning of industrial areas and the relevant urban planning laws.

The industrial site will be developed in barren land with environmental factors playing a major part in land use distribution and design of land use pattern. These environmental factors are the basic elements of the master-plan concept. Natural conditions, existing and proposed man-made environment are analyzed in the following section.

5.1 Site Suitability for Different Uses

Space and environment demands for different land uses will be restricted by the following natural and man-made elements:

5.1.1 Topography

Undulating land more than 3% are defined as natural boundaries for industrial development and more than 5% for residential development.

5.1.2 Vicinity

The parts of the site most integrated with the urban vicinity should be provided for housing, and recreation areas in an effort to integrate the housing with the structure of the existing urban community. Fig (5.1) shows the site edge, entrances and services. It has been requested that the eastern region be reserved for housing and the western region for industry.

5.1.3 Intruding Elements

The railway tracks are strong man-made boundary dividing the site into two parts. The tracks have to be integrated into the development strategy, to utilize its potential and to avoid disturbance. The rail buffer shall consume 5.08% of the development occupying 30874 m^2. The dumpsite to the south of the site, although extends into the site 10343 m^2 is expected to developed once the leveling of site is under-way.

The suitability of the different zones of the site for land use are judged according to the following:

a. Disturbances by Adjacent Land Uses

Industrial pollution could occur from neighboring developments especially quarries and the refuse management facility planned to the north (as shown in chapter 2). Adjacent sites are reserved for progressively polluting industries.

b. Climate

Suitable sites that provide necessary protection should be used for housing. Sites with fewer qualities might be used for the exceedingly polluting industries.

c. Nature of Land Use

The allocation of different land uses, i.e. large and small industries are affected by the nature of the industry size. Large plots are less adapted to irregularly edged sites, while small plots are more flexible.

5.2 Demands

5.2.1 Maximum and Minimum Densities

As a basis for determination of space demands, the maximum and minimum ranges for pollution, employment and building densities are fixed. The minimum ranges are defined by the conditions of economical land utilization, i.e. utilization of planned infrastructure, as well as minimizing implementation and maintenance costs of the networks. Maximum ranges are defined according to infrastructure capacities and hygienic conditions that must be guaranteed for comfort and to prevent over-crowding.

a. Employment Densities

The specific employment densities, i.e. employers and employees per ha., differ according to the needs of different branches. In industrial areas, about 25 employees/feddan gross area shall be assumed.

Although the above estimates are well taken, it is important to point out that the level of implemented technology and the amount of capital investment available might alter employment densities.

b. Sector Planning

The distribution of land uses for the industrial site should follow Egyptian norms. It is expected that the nature of the site: i.e. edge delineation shall render about 8% of site ineffective on the perimeter to be used as green areas.

c. Industrial Density

Based on above, the employment density of 25 worker/feddan is occupying industrial plots covering 75% of the industrial site as represented by the western region. The plots are distributed among the various industry sizes with the expectation of increased utilization as the industry size increases.

The request to provide front and back streets to industrial facilities, in an effort to enhance the internal organization of the production process, will also reduce the utilization factor of plots. It is estimated that the utilization factor will range from 40% to 70% according to size.

d. Residential Density

Based on the experience of other planning projects in Egypt (shown in appendix I) and elsewhere regarding economic and technical studies on land use distribution and settlement policy, the overall density for the residential district shall be slightly less than the maximum allowable 150 inhabitants/feddan. The residential district shall be located in the eastern region occupying about 22% of the area.

e. Services

Previous studies indicate that 5% of the usable land should be allocated to services including social, administrative and emergency. Central services, including police, fire brigade, health, environmental protection, estate management and transportation, shall occupy 3% of the area. Additional, substantial industrial and residential services shall be provided within respective regions. Area for total services is about 15% of designated area.

5.2.2 Space Demands

a. Industries

One of the main planning goals is to develop the industrial site as an efficient and sustained settlement. The efficiency has been taken in consideration in providing additional roads to enhance the production process and the sustainability is ensured with the sufficient supply of industry specific services. The provided services include waste transfer station, central raw material storage, extended and overnight parking, transport and fuel station. It is expected that the distribution of land uses in the industrial region be as follows: net industrial plot area 43%, roads 36%, services 10% and green areas 11% of western region areas.

b. Residential

The Space Index and Floor Area Ratio (FAR) determine land utilization. According to international standards, space indices are set at 0.5 for residential areas and FAR are calculated at 2 to approach the density limit of 150 persons/feddan.

The capacity of the residential area, calculated on the basis of 87 buildings, 4 stories, 600 plot area, 0.5 building coverage (index) and about 23 m^2 gross floor space per capita, would amount to 5568 inhabitants.

Provided residential services include educational facility to be used as school or an industry specific training center, bank, postal service, communication center, religious facility, commercial center and youth playgrounds. It is expected that the distribution of land uses be as follows: residential plots 42%, roads 31%, services 17% and green areas 10% of eastern region area.

c. Services

The importance of services cannot be overemphasized especially in industrial projects with homogeneous industries. The need for industry specific services is necessary for the sustainability and profitability of the facilities located.

Services allocated, as mentioned above, include central, industrial and residential services representing 14% of the project area. It is expected that the distribution of services be as follows: central services 20%, industrial services 53%, and residential services 27% of the total services provided in the project.

d. Green and Recreation Areas

One of the major problems of the site is related to the allocation of open spaces. The plot requirements for industries in relation to the irregularity of the site shall force the planning efforts to set aside portions of land as unusable and possibly available as open spaces and green areas. It is expected by the nature of the problem that the majority of these spaces will be located on the periphery of the site. It is estimated that the amount of green area arising from unusable spaces reach 8%.

The strategy for green areas is to rely on the vegetation in the street-scape rather than dedicated parks to enhance the project. The area provided by the streets, 34% of project area, greatly exceeds park planning 10%. The distribution of streets in the industrial area also provided the opportunity to utilize tall trees to set off the effect of stacks thus enhancing the overall visual impression. Nevertheless a central recreation park is demanded along with green spaces within the residential areas for children and families.

5.3 Zoning

- The nature of the project and the demands to allocate the eastern region for residences and western for industries, in an effort to integrate the project with the surrounding region, has pre-specified the overall zoning condition.

- The topography and climate place limited restriction on zoning within the eastern and western regions. The topography has negligible effect as there is no contour with inclination exceeding 3% other than the southern edge of the western region. The topography neither affects the zoning of industrial or residential areas. The climatic factor shall effect directly the location of industries as generated pollution is considered.

- The functional order and accessibility to the site has also limited effect on the zoning. The homogeneity of industries to be allocated has negated any preoccupation with diversity of industries. Moreover, the predefined separation of residences and industries has structured the provision of services with high accessibility.

In traditional planning the proximity of high-density industries to residential areas reduces travel costs. In Abu-Zaabal project, this zoning principal shall be tentatively acknowledged pending environmental assessment.

5.4 Land Use Pattern

5.4.1 Grid Systems

Using a grid system in land use development is a controversial issue in town planning ideology. Unless a grid system is sufficiently flexible to provide a wide range of possibilities for individual urban and building design, it could cause a dull and endless repetition of settlements.

However, a design on a suitable grid system facilitates land survey and implementation and finance of the different infrastructure systems.

5.4.2 Layout of Industrial Plots

a. Planning Principles

The area of an industrial site, occupied factories, should satisfy three demands: an area of land satisfying immediate and short-term operational requirements, addition land, ideally adjacent to the initial factory, satisfying needs of possible long-term expansion; and a siting alongside other industrials whose activities or requirements will enhance rather than conflict with the successful pursuance of its own operation.

For the promoting agency, the principles are: a system of land subdivision and site allocation that will meet industrialists' requirements and thereby achieve a successful promotion and development of the settlement; and a system that meets the above criteria and at the same time optimizes government investment into infrastructure and maintenance.

b. Block Planning

The method used for sub-dividing land for factories in respect to Abu-Zaabal site is based on a system of block planning. This system divides the land for foundries into a number of large rectangular blocks delineated by service roads and site boundary. Each block is subdivided into land parcels in the form of strips for the purpose of allocating plots to individual industrial establishments.

Six standard sizes are recommended: 20, 25, 35, 60, 100 meters in depth serving small workshops (200 m^2), medium workshops (500 m^2), large workshops (1000 m^2), small plots (2000 m^2), medium plots (5000 m^2) and large industrial plots (10,000 m^2 and up).

Although urban planning law 3/1982 states that plots are to be serviced by a single street except for corner plots, there was a direct request to supply front and back entrances, which has negated the back-to-back arrangement specific to block planning as shown in fig (5.2).

The above-recommended sizes are subdivided into strips. In Abu Zaabal case where the plots are pre-specified the blocks are divided into the required plots. As a rule the allocation of site will follow the following criteria:

1. The minimum width of site shall not be less than 0.5 of its depth.
2. The maximum width of site shall not exceed its depth.

c. Coping with Expansion

One of the main advantages of an industrial city is that it can offer an industrialist greater flexibility in factory accommodation than is generally possible elsewhere. It can take account of the growth and changing requirements over time of an industrial establishment and the very lack of this facility in existing locations often causes many enterprises to seek accommodation on an industrial site. Given the particularity of the task where the required plots fills the site, expansion can only be recommended as long term expansion to the west and south.

d. Zoning and Location Criteria

Zoning is the process by which particular activities are allocated to specific areas in order to reduce operational conflicts and to encourage the grouping of complementary activities.

In making zoning recommendations for Abu Zaabal industrial site, the following points are of significance:

- the activities identified in the allocated industries are broadly described as polluting;
- few of the identified industries may be termed less polluting;

For the above, reasons it was decided not to zone the plots in the sense of allocating specific areas for specific activities. Instead, it is recommended that zoning follow a mixed use to separate the polluting industries thus lessening the concentration of pollutant.

Traditional planning principles necessitate that the higher the polluting power the southern the location of industries. It is assumed that the larger the industries the higher the production and thus the higher the pollution. In allocating the industries, the larger industries are placed south of the site downwind. Traditional planning principals also necessitate that the industrial settlement be zoned by size of establishment and worker density. It is a general axiom that the smaller an industrial establishment the higher the density of workers. This stems from the fact that small industries tend to be labor intensive rather than capital intensive, the reverse tends to apply to large industries. The recommendation on block design indicates that the smallest industries will be located in the 20 m depth blocks and the largest in 100 m depth blocks. In organizing the layout of the estates design, criteria were adopted whereby the smaller blocks were grouped close to the residential district with the larger blocks in more peripheral locations. These arrangements minimize average walking distances and maximize accessibility to the central facilities and sub-central facilities. A further advantage is that small industries, which will generally not be able to offer a wide range of worker facilities, will be within easy walking distance of services.

5.4.3 Residential District

As the residential portion in the development reaches a size of a neighborhood, the services to be provided shall encompass traditional neighborhood functions as specified above. The maximum distance to services especially commercial facilities should not exceed 500 m. and to public facilities 1000 m.

Taking into consideration the above grid systems, the neighborhood development were based on the following design principles:

- Neighborhood shape should be as compact as possible while locating inner private green areas
- Road development should be minimized to keep costs low
- Pedestrian and car routes should be separated to avoid mutual disturbance
- Service facilities should be near
- Accessibility should be easy and safe from all directions
- Through traffic should be avoided.

5.4.4 Service Facilities

The principal task of service facilities and private trade institutions will be to provide the inhabitants and employees of the industrial settlement with necessary services and goods, as well as employment opportunities. Sufficient supply and temporal realization of service and goods is required of industry specific services.

Accessibility to service facilities should be heightened. Facilities should be located at suitable distances to housing units and in central areas of the settlement industrial sectors. These central areas should in turn be developed as recreational meeting places where inhabitants can identify with community life.

Service facilities must be located within easy and safe access, minimal distances for pedestrians and affordable car connections for trade deliveries.

The diversity of service facilities should be maximized. Centralized facilities are features that distinguish any industrial site from any other. It is the provision of these services, in addition to the basic land or factory building, which increases the attraction to industrialist and worker alike. The types of services recommended for inclusion in the designated site may be summarized under the following headings:

- Worker services: These services are aimed at the work force, looking to satisfy health, welfare, recreational and day to day requirements. The buildings proposed to meet these demands comprise a health clinic, mosque, recreation center, shops, post office, telephone and telegraph office and bank.

- Factory support services: Of critical importance to the proper functioning of an industrial city are services that ensure safety, security and smooth running of the industrial establishment. To satisfy these basic requirements, a fire station, a police station, health facility, fuel as well as service garage are proposed.

- Administration services: The key to the effective operation of an industrial estate is its administration service including estate management and environmental protection. A single administration center is proposed to accommodate the personnel who will be engaged in this role.

It is recommended that a distinction be made between 'emergency' facilities such as fire station, police station, health care, traffic department, and maintenance facility, and other 'non-emergency' facilities such as post office, bank, administration, mosque, recreational center, and shopping. The design of central spaces around which non-emergency facilities congregate will supply the settlement with identity. Emergency facilities, on the other hand, are located at main points of access.

Sub centers should be provided within both the industrial sectors as well as residential neighborhoods. In the industrial sectors, these sub-centers provide daily food services as well as technical assistance for industries. In the residential district, they provide daily and weekly services for the inhabitants.

5.5 Traditional Scheme

According to the traditional planning principles discussed in section (5.4), a scheme was formulated. This traditional scheme, shown in fig. (5.3) was the starting point towards the final master plan. The concept was guided by the nature of the site and the respect for the vicinity.

The railway tracks divide the site vertically into a distinct western and eastern region each with its unique boundary. The link can only be maintained by crossing the tracks. The demands of allocating the eastern region for residences and western for industries set the overall zoning pattern.

The direction of most disturbing winds are north-western to north-eastern (see chapter 2). And thus consequently, the more pollution an industry generates the southern the location it gets. The large industries are located south most, edged to the north by medium industries and so forth reaching to the northern locations of the site.

The primary road bordering the site from the east and linked to the "agricultural" Cairo-Ismailia road, presents the only access to the site. The access to the residential area is separated from access to the industrial region. Internal links are available in-between.

Masaken Abu Zaabal borders the eastern edge of the site offering a live community with its social commercial and educational services. Taking into consideration the relative location of the neighbors to the east, the demand for locating the residential area there would enhance the community as well as give access to the residences of the industrial site avoiding the obvious location deep in the industrial site.

This scheme was discarded since small foundries are the ones using fossil fuel and thus emit large quantities of emissions.

Chapter 6
Impacts of the Air Quality of Generated Alternatives

Mathematical modelling is used to predict the ambient quality for each proposed urban planning alternative in order to reach an optimum layout for the different industries ensuring the best possible ambient quality. The critical pollutants include sulfur dioxide, dust, lead and carbon dioxide. Certain technological and environmental constraints were imposed to avoid deterioration of Abu Zaabal environment. The imposed restrictions include adopting modern melting technologies for large foundries, installing air pollution control equipment, restricting operation periods and other conditions.

The selected scheme yielded satisfactory results for all pollutants and the impacts of air quality on public health and biological life were identified.

- ***No Impact on Public Health***
  The concentrations of pollutants reaching the residential areas are well below the corresponding allowable limits representing no hazard on public health.

- ***No Impact on Agricultural Land***
  The agricultural land is located 2 km to the north and pollution concentrations do not extend to reach this area.

- ***No Impact on Fauna or Flora***
  Wild animals and plants in the area are tolerant of pollution loads

- ***No Impact on Domestic Animals***
  Livestock and poultry farms are located 4 km away north of the industrial site and will not be affected by air quality in the area.

In order to maintain the environmental quality of the area and prevent deterioration of air quality, monitoring, inspection and enforcement mechanisms should be in place.

6.1 Critical Pollutants

Gaseous emissions resulting from foundries operations include several pollutants that may affect the ambient air quality in the area. The most important emitted pollutants are sulfur dioxide, carbon monoxide and particulate matter including metal oxides such as copper, aluminum, iron and lead oxides. Law 4/1994 gives the maximum allowable limits for these pollutants taking into consideration the health effects associated with the exposure to these pollutants such that any exposure to a concentration less than the law allowable limit is considered not to cause any harmful biological or health effect.

6.1.1 Particulate Matter (PM)

Sources of particulate matter are the furnace and shakeout unit. These particles include metal oxides such as aluminum, lead, copper and iron oxides, silicon dioxide and calcium oxide. Tables (6.1, 6.2) give the particle size distribution of the particulate matter in iron foundries and lead smelters respectively.

Table (6.1) Dust Particle Size Distribution for Iron Foundries

Source	Particle Size (μm)	Cumulative Mass Percent
Cupola Furnace	0.5	44.3
	1	69.1
	2	79.6
	2.5	84
	5	90.1
	10	90.1
	15	90.6
		100
Induction Furnace	1	13
	2	57.5
	5	82
	10	90
	15	93.5
		100
Shakeout	0.5	23
	1	37
	2	41
	2.5	42
	5	44
	10	70
	15	99.9
		100

Source: EPA, Background Report, AP-42, Iron Foundries,

Table (6.2) Dust Particle Size Distribution for Secondary Lead Smelters

Source	Particle Size (μm)	Weight Percent
Rotary Furnace	1	13.3
	2	45.2
	3	19.1
	4	14
	16	8.4

Source: EPA, Inspection and Operation Maintenance Guidelines for Secondary Lead Smelter Air Pollution Control, 1984

6.1.2 Sulfur Dioxide

The main sources of sulfur dioxide are furnaces using fossil fuel where about 60% of the sulfur content in the fuel react with oxygen forming sulfur dioxide, the remaining 40% comes out in the slag. Based on material balance calculations, using wet scrubbers of average efficiency 80% will reduce sulfur dioxide concentration to an average concentration of 200 mg/m^3.

6.1.3 Heavy Metals

Heavy metals are usually emitted from stacks in the form of dust and fumes. Lead and copper are the heavy metals that may have significant impacts on the human health and biological life. However, lead is the most important because:

- Lead is not one of the essential elements for any organism and has no known biological function. It is toxic in man and other organisms

- Lead has toxic effect on all organisms, in addition to its cumulative character (biological magnification) in the biological systems, soil and water.

- Compounds of lead are the most prevalent metal hazardous air pollutants (HAPs) in secondary lead smelter emissions. There will be three lead smelters transferred to Abu Zabaal site with total production 37500 ton/year.

- Lead is concentrated in the smaller sized fractions of particulate matter, which are the most difficult to control. Therefore, controlling lead will also control other metal particulates.

According to the EPA 1994 Toxic Release Inventory, aluminium and iron are not classified as metal compounds having potential adverse human health and environmental effects. Table (6.3) gives the major heavy metal in dust emitted from each foundry.

Table (6.3) Percent of Heavy Metals in Dust

Foundry	Main Dust Component	Weight Percent
Iron Foundries	Iron	70
Copper Foundries	Copper	30[5]
	Zinc	70
Lead Smelters	Lead	90

Cadmium is a toxic metal that usually evolves, in the form of dust, from primary smelters and secondary zinc smelters. Cadmium is a toxic heavy metal that may have acute health effects. Humans are exposed to cadmium by food and air. In Abu Zaabal, the scrap used in the foundries is rarely contaminated with cadmium since the foundries do not include zinc foundries. Cadmium may be emitted from iron foundries only when using galvanized steel scrap, which usually represents a very small percentage of the scrap. Moreover, cadmium is not used during the manufacturing processes, which makes it unlikely to have cadmium dust or fumes in the flue gases. Thus, cadmium emissions are not taken in considerations in modelling.

6.1.4 Carbon Monoxide

Carbon monoxide is an unburned gaseous combustible emitted from the furnace but generally in small amounts. Usually, the amount of emitted carbon monoxide is reduced through air to fuel ratio adjustment.

6.2 Modelling

Modelling was used as a scientific simulation tool to predict the potential impacts of each site alternative on the ambient quality, based on emission factors and meteorological data. According to modelling results, alternatives were discarded, modified or upgraded in order to reach an optimum layout for the different industries and utilities ensuring the best possible ambient quality.

6.2.1 Theory

The Gaussian Plume Model was used to calculate ambient pollutants concentrations (C in kg/m^3) as a function of the three co-ordinates (x, y, z) according to the following equation:

$$\mathbf{c(x,y,z)=\frac{Q}{2\prod U\sigma_y\sigma_z}e^{\frac{-y^2}{2\sigma_y^2}}\left(e^{\frac{-(Z-H)^2}{2\sigma_y^2}}+e^{\frac{-(Z+H)^2}{2\sigma_z^2}}\right)} \qquad \textbf{(1)}$$

5 According to an analysis conducted by EEAA Central Laboratory for a copper foundry in 1998. Zinc concentration was assumed to be 70% of the total particulate matter

where:

Q: mass flow rate of continuous emissions in kg/s
U : wind velocity at the emission height in m/s
σ_y&σ_z: variance of the horizontal and vertical positions of a certain particle emitted from the stack.
X: distance downwind along the plume axis starting from the stack location, m
Y: perpendicular distance crosswind starting from the center of the plume
Z: height above the ground, m

The dependence of the concentration on x co-ordinate is clear in the σ_y and σ_z functions since they are both functions of x. The term between brackets in equation (1) represents the effect of plume reflection at ground level. The Gaussian Plume Model is a solution to the diffusion equation at constant wind velocity and constant diffusivity K.

For ground level concentration (Z = 0), the equation (1) reduces to:

$$\mathbf{c(x,y,z) = \frac{Q}{\prod U \sigma_y \sigma_z} \left(e^{\frac{-y^2}{2\sigma_y^2}} + e^{\frac{-H^2}{2\sigma_z^2}} \right)} \qquad \textbf{(2)}$$

σ_y and σ_z function are given by the following equations:

$$\sigma_y = \mathbf{0.22X(1 + 0.0001X)^{-0.5}}$$

$$\sigma_Z = \mathbf{0.2X} \qquad \textbf{(3)}$$

In equation (2), H is not the stack height but the effective plume height which is the sum of the plume rise (Δh) and the stack height (H_s). The following equations were used to calculate the plume rise.

$$\mathbf{\Delta h = 2.3F_{mo}^{1/3}U^{-2/3}X^{1/3}(1 + F_oX/2F_{mo}U)^{1/3}} \qquad \textbf{(4.1)}$$

$$\mathbf{\Delta h = 2.9(F_o / US)^{1/3}} \qquad \textbf{(4.2)}$$

where:

F_o: initial buoyancy flux
F_{mo}: initial momentum flux
S: stability parameter

Equations (5,6,7) give the values for F_o, F_{mo}, S respectively.

$$\mathbf{F_o = V_o\left(g/T_{vpo}\right)\left(T_{vpo} - T_{veo}\right)} \qquad \mathbf{(5)}$$

$$\mathbf{F_{mo} = V_o w_o} \qquad \mathbf{(6)}$$

$$\mathbf{S = g/T\left(\frac{\partial T}{\partial Z} + 0.01\right)} \qquad \mathbf{(7)}$$

where:
V_o: initial volume flux (m^3/s)
w_o: initial vertical velocity (m/s)
T_{vpo}: initial potential temperature of the plume (°K) respectively.
g: acceleration due to gravity (m/s^2)

A safe reasonable estimate for Δh, according to the characteristics of the emissions flow rate and temperature, is in the range of 30-35 m.

In case of particles, since they are heavier than air, a sedimentation velocity should be added, as a vertical component to the dispersing plume. The sedimentation velocity is calculated according to the following equation:

$$\mathbf{V_s = \frac{2}{9} g\ r^2 \rho_s / \eta} \qquad \mathbf{(8)}$$

where:

r: equivalent particle radius in m
ρ_s: particle density (kg/m^3)
η : dynamic air viscosity (kg/ms)

For short stacks, or, gas vents emitting gases with dust particles (the concentration at air is calculated according to:

$$\mathbf{C_{air} = \frac{2Q}{U 1_B^2}} \qquad \mathbf{(9)}$$

where:
C_{air}: concentration of pollutant in the air between factories resulting from the flush vents alone. It has to be added to the concentration field resulting from large stacks to obtain the total concentration field.
1_B: smaller of h_B (height of the highest building in the factory and width of the industrial structure (w_B).

6.2.2 Main Criteria

All proposed urban planning alternatives and modelling calculations are based on the following criteria. These technological and environmental criteria should be adopted and agreed upon by all concerned parties since they represent necessary conditions for avoiding environmental deterioration in Abu Zaabal.

1. Wet scrubbers, with a removal efficiency of at least 80%, will be used to clean the flue gases and reduce SO_2 concentration to an average concentration of 200 mg/m^3 in case sulfur-containing fuel is used. The wet scrubber will also help to decrease the concentration of particulate matter to the allowable limit.

2. All foundries will at least be complying with law 4/1994 allowable limits for stack emissions such that the concentrations of pollutants in the flue gases are as shown in table (6.4).

Table (6.4) Concentration of Pollutants in Flue Gases

Parameter	**Concentration in Flue Gases**	
	in mg/m^3	**in Kg/m^3**
CO	2500	$25*10^{-4}$
SO_2	200[6]	$2*10^{-4}$
Dust and Soot	100	10^{-4}
Lead	20[7]	$2*10^{-5}$
Heavy Metals	25	$25*10^{-6}$

3. Large foundries will use induction furnaces, which emit the least amount of flue gases compared to other furnaces and its emissions can be negligible with respect to the other furnaces. This criterion is practical since a number of large foundries in Shoubra El Kheima already use induction furnaces.

4. Night shifts (10 p.m.- 7 a.m.) are not allowed to avoid noise pollution and early morning fumigation.

5. Furnaces using fossil fuel will only operate for 10 hours per day, during the period from 7a.m. to sunset. At night, the top of the stable boundary layer will be close to the ground and flue gases from stacks will be entrapped between the ground and the stable layer resulting in very high concentration. It is allowed to operate induction furnaces for 24h as an incentive for using such clean technology that emits negligible emissions.

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[6] Note that SO_2 concentration in emissions is far less than the allowable limits

[7] Analysis provided by CAIP had shown that it is possible to reach such concentration and even less using control measures.

6. Stack height should never be less than (h_B + 1.5 I_B) where h_B is the height of the highest building in the factory and I_B is the smaller of h_B and w_B (width). The stack height of melting furnace and ladle preheating should not be less that 30m and that of the shakeout unit should not be less that 25m. These represent the minimum safe height of stacks below which the gases will b introduced to the wake region of the formed turbulence.

7. According to law 4/1994, using fuel oil (mazot) is forbidden since the site includes, and adjacent to, residential areas.

8. Operation should be prohibited when the weather is very calm.

9. The number of relocated foundries is only 90 and the free plots are not to be used for relocating more foundries or other polluting industries.

6.2.3 Model Assumptions

1. A worst case scenario was selected to identify the ultimate constraints and as a precautionary measure to overcome the inherent inaccuracy of simulation models:
   - All factories (except those using electricity) use fuel with sulfur content (1%), as an average between coke (3% sulfur) and solar (0.5% sulfur). It was assumed that solar is used for ladle preheating in all foundries and coke is used in melting in case of iron foundries and solar is used in case of copper and aluminium foundries. In case the industrial estate is provided by natural gas (0% sulfur), calculations should be repeated taking into consideration the number of foundries that would switch to natural gas.
   - The production capacity has reached the figures listed in chapter 1. As already stated, these are 2-3 times higher than the current production of foundries to be relocated and would take a number of years to reach these production levels.
   - Concentration fields were calculated using a wind velocity of 1m/sec, assuming sunny weather [8]. This low wind velocity causes the dominance of thermally induced turbulence and weakness of mechanically induced turbulence. This affects the horizontal and vertical spread of the plume, which becomes the highest, compared to other weather conditions and the plume hits the ground at much closer distance at the stack location[9].

2. For modelling purposes, in case of 1000 and 500 m^2 foundries of which some produce iron and others produce aluminium and copper, the emissions were calculated such that each foundry produces both ferrous and non-ferrous castings in the same proportion as the

[8] 1m/sec represents the average of the worse 20% probability of occurrence, which corresponds to case A in the Pasquil-Gifford-and Turner (PGT) curves.

[9] In case of certain meteorological conditions where the weather is very calm, production should be stopped

production capacity of foundries of the same area. The modelled flow-rates become therefore as shown in table (6.5).

Table (6.5) Flow Rate of Flue Gases from Foundries*

Foundry Area in m^2	**Gaseous Emissions in Kg/hr from Stacks of**		
	Melting Furnace	**Ladle Preheating**	**Shakeout Unit**
15000	negligible[10]	2000	2000
10000	negligible	2000	2000
5000	negligible	2000	2000
2000	7000	2000	2000
1000	2000	750	750
500	1670	835	835
200	250	250	250
Temperature, °C	90**	90	25
Stack Height, m.	30	30	25

* according to tables (1.1, 1.2, 1.3) in chapter 1
** temperature after the wet scrubber

3. Lead smelters are considered as one source because the governorate has already allocated land for the three smelters in close proximity to each other. Table (6.6) gives the flow rates of flue gases from the lead smelters.

Table (6.6) Flow Rates of Flue Gases from Lead Smelters

Total Area of Lead Smelters in m^2	**Gaseous Emissions in Kg/hr from Stacks of**	
	Melting Furnace	**Refining**
20500	12000	6000
Temperature, °C	90*	90
Stack Height, m.	30	30

* temperature after the wet scrubber and bag house

4. Owing to the fact that not all the factories operate at full capacity at the same time, it was assumed that foundries operate at half their capacity all the time.

5. Modelling results did not take the background concentrations into account. The results should be superimposed to the background concentrations to reflect actual ambient concentrations of pollutants. Possible pollution sources are the Fertilizer Company south east of the site and the dumpsite. Emissions from the Fertilizer Company may reach the residential area, east of the site, when the wind direction is south. The concentrations of these emissions are not likely to be high due to the large distance between the company and the residential area. There will be not interaction between emissions from the industrial site and those from the Fertilizer Company since the former occur when the wind direction is west.

[10] Emissions from induction furnaces are negligible with respect to those of other furnaces

Possible exposure to odors and emissions will be from the dumpsite where garbage is burned emitting fumes and dust. This site should de dveloped before the construction works begin. However, the measurements undertaken by CAIP close to the dumpsite indicated that sulfur dioxide concentrations are not critical.

6. The upper boundary for the mixing layer[11] was assumed at 1000 m.

7. The horizontal distance x was taken as 4 times the stack height (H_s) which agrees with the value of plume rise (Δh) obtained from equation (4.2). Another equation for calculating x (10* H_s) is indicated in literature, which yields an improvement of 33% in the modelling results. This equation is not used since it gives a very high value for Δh, which contradicts the plume rise usually seen in reality.

8. It is well known that the density of a certain gas (ρ) is inversely proportional to its temperature. Although the temperature of flue gases are considered 90°C (ρ_{gases}: 0.9 Kg/m^3), their density is taken as if they are at 300°C (ρ_{gases}: 0.616 Kg/m^3). This will cause an increase in the gases volume and the modelling results will be 33% worse than the reality, which is considered as a safety factor.

10. Air borne particultates, from ground pollution, is not taken into considerations because ground pollution is mitigated by central stores and transfer station and enforcement of paving and good housekeeping.

The model calculations were conducted for eight wind directions (north, north-west, west, south-west, south, south-east, east, north-east. Modelling results were compared to law 4/1994 maximum allowable ambient air concentrations shown in table (6.7). The results are represented in the form of contour maps that give the concentration for PM10, lead, sulfur dioxide and carbon monoxide as a factor of the corresponding maximum allowable concentration. Maps for dust deposition are given in kg/m^2.s.

Table (6.7) Maximum Allowable Ambient Air Concentrations

	Maximum Allowable Limit as Stated in Law 4/1994		**Exposure Time**
	in mg/m^3	**in Kg/m^3**	
CO	10	1.0*10^{-5}	8 h
SO_2	150*10^{-3}	1.5*10^{-7}	24 h
Dust and Soot (PM10)	70*10^{-3}	7.0*10^{-8}	24 h
Lead	1*10^{-3}	1.0*10^{-9}	1 year

[11] Height at which reflection occurs

6.3 Alternatives

In chapter 5, a traditional scheme for foundries distribution was discussed and discarded due to its obvious negative environmental effects. A number of urban planning alternatives were generated based on the above mentioned criteria and principles agreed upon with the client (stated in chapter 4) concerning having two entrances, on two different streets, for each foundry. The alternatives represent different iterations for industrial activities distribution schemes in the site Several alternatives were discarded due to their extremely negative environmental effects. The selected alternative was the most environmentally sound scheme.

In the following, the selected alternative will be discussed together with the last two generated alternatives to demonstrate the mechanism followed in generating alternatives.

6.3.1 Alternative I

a. Alternative Description

The scheme for this alternative is shown in fig (6.1), where the main features are:

- Large foundries of areas 15000, 5000 m^2 are located adjacent to the railway lines in 2 rows

- Foundries of areas 10000, 2000 m^2 are located in a third row (close to the northern west border of the site)

- Smaller foundries of areas 1000, 500, 200 m^2 are located in the south such that 200 m^2 foundries are located close to the south-west border of the site.

- Foundries of areas greater than 2000 m^2 use induction furnaces such that the flow rates of flue gases are the same as table (6.5).

b. Predicted Pollution Loads

Figures (6.2, 6.3, 6.4, 6.5) shows the concentration profiles of sulfur dioxide, carbon monoxide, dust and dust deposition respectively, when the wind direction is west, since this the most critical direction as where the wind blows towards the project residential area and Masaken Abu Zaabal. The results have shown that:

- In different wind directions, the concentrations of sulfur dioxide range from 0.6 times the allowable limit (wind blowing from the east and the west) to reach 1.2 times with southern and northern winds (because of the superimposition of pollution resulting from the different sources).. In possible cases of non-compliance, this concentration will reach about 3 times the allowable limit.

- Dust concentrations reached a value of 0.7 the allowable limit. In case of wet scrubber malfunction, an increase of 50% of this concentration will violate the ambient air standards.

- Carbon monoxide concentrations reached a maximum of 0.45 of the allowable limit.

The alternative was rejected due to its negative environmental impacts, especially concerning sulfur dioxide.

6.3.2 Alternative II

a. Alternative Description

Alternative II, shown in figure (6.6), has the following features:

- Foundries of areas 15000,10000,5000 m^2 are located in two rows adjacent to the railway lines in the eastern part of the site.

- Foundries of areas 200,500,1000 m^2 are located in one row at the west-north side of the site.

- Foundries of area 2000 m^2 are located at the southern side of the site.

- Foundries of areas greater than 2000 m^2 use induction furnaces and the flue gases flow rates are according to table (6.5).

b. Predicted Pollution Loads

Concentration contour lines for this alternative in case of west wind direction are shown in figures (6.7, 6.8, 6.9, 6.10). The results have indicated that:

- In different wind directions, the maximum sulfur dioxide concentration showed the same pattern as alternative I and ranged from 0.6 times the allowable limit to reach 1.1 times, for wind blowing from the north or the south. This level is still critical especially in cases of non-compliance or wet scrubber malfunction.

- Dust concentrations reached a maximum of 0.5 the allowable limit.

- Carbon monoxide reached a maximum of 0.2 the allowable limit.

This alternative gave marginally better results than the alternative I, yet it does not satisfy the environmental and health standards especially with respect to sulfur dioxide that appears to be the limiting case. This alternative could have been selected in case the industrial estate is provided with natural gas (zero sulfur content).

6.3.3 Selected Alternative

a. Alternative Description

In an attempt to decrease sulfur dioxide concentrations, alternative II was modified by considering the following technological and positional variations:

- Foundries of area 2000 m^2 should use induction furnaces. This will minimize pollution load and concentration from such sources since the flue gases resulting from melting process in these foundries can be negligible and table (6.5) will be modified accordingly such that emissions resulting from the melting furnace of these foundries are negligible.

- Pollution load resulting from foundries of 200, 500 and 1000 m^2, still using fossil fuel, could be distributed by dividing these foundries in two areas such that foundries of area 1000 m^2 will be in the south east of the site and those of 200 and 500 m^2 will be in the north west as shown in fig (6.11).

b. Predicted Pollution Loads

The alternative was found to be the most environmentally sound alternative and gave satisfactory results for all investigated pollutants. For this alternative, results for three wind directions are included; south direction (6.12, 6.13, 6.14, 6.15), west wind direction (6.16, 6.17, 6.18, 6.19) and north direction (6.20, 6.21, 6.22, 6.23). The results had shown that:

Sulfur Dioxide

In all wind directions, sulfur dioxide concentrations are within the maximum allowable limit of law 4/1994 (150 $\mu g/m^3$, for an exposure time of 24h.). The maximum concentration for north wind direction is 0.6 of the allowable limit decreasing to 0.4 in east wind direction and rising to 0.5 for south wind direction. The ambient concentration will still be around the law limit even when doubled (to 400 g/m^3) in possible cases of noncompliance or wet scrubber malfunction or when loads are doubled in the unlikely case of all –complying- foundries function at the same time.

PM10

In all wind directions, ambient dust concentrations were found to be less than the maximum allowable limit of law 4/1994 (70 $\mu g/m^3$). The concentrations reached a maximum of 0.3 of the allowable limit in case of south wind direction decreasing to 0.2 in case of west wind direction and increasing back to 0.3 in case of north wind direction. The ambient concentration will still be below the law limit even when it is doubled in possible cases of noncompliance or wet scrubber malfunction.

Carbon Monoxide

Carbon monoxide concentrations are much less than the maximum allowable limit of law 4/1994 (10 mg/m^3 for an exposure time of 8 hr.). The maximum concentration for north wind direction is 0.24 the allowable limit decreasing to 0.15 for east wind direction and rising again to 0.24 for south wind direction. In case of east wind direction, carbon monoxide concentration reaching the residential area is 0.11 and that reaching Masaken Abu Zaabal area is about 0.09 causing no impact on the air quality of the area. In cases of non-compliance, which is quite possible, an increase of 400% of ambient carbon monoxide concentrations will still represent no problem. Moreover, carbon monoxide concentrations can be easily controlled by means of adjusting air to fuel ratio.

Lead

In all wind directions, the average yearly ambient lead concentrations are found to be within the allowable limit of law 4/1994 (1μg/m^3). Figures (6.24) show contour lines for lead concentration (in μg/m^3), in case of west wind direction, for an exposure time of 24h. For each wind direction, concentrations for an exposure time of 1year is calculated by dividing the concentration by an average wind speed and multiplying the result by the average occurrence of this wind direction. Table (6.8) gives the maximum lead concentration, for annual exposure time, for each wind direction.

Table (6.8) Maximum Predicted Lead Concentration in All Wind Directions

Wind Direction	Yearly Maximum Ambient Lead Concentration in μg/m^3
North	0.118
North East	0.063
East	0.0273
South East	0.021
South	0.047
South West	0.04
West	0.04
North West	0.16

Copper and Zinc

Copper and zinc concentrations were calculated although law 4/1994 does not provide allowable ambient limits for them. Calculations have shown that yearly copper concentrations are in the range of 0.03-0.15 μg/m^3 and 0.12-0.68 for zinc. These ranges are considered to be acceptable compared to the lead limit (1 μg/m^3) with its adverse health effects, taking into consideration that copper and zinc have no such effects and neither EPA nor WHO has appointed maximum allowable limit for them. Table (6.9) gives the maximum copper and zinc concentration for each wind direction.

Table (6.9) Maximum Predicted Copper Concentration in All Wind Directions

Wind Direction	Yearly Maximum Ambient Copper Concentration in $\mu g/m^3$	Yearly Maximum Ambient Zinc Concentration in $\mu g/m^3$
North	0.15	0.68
North East	0.14	0.36
East	0.08	0.15
South East	0.03	0.12
South	0.05	0.27
South West	0.05	0.23
West	0.05	0.23
North West	0.15	0.67

6.4 Impacts Resulting from Air Quality of Selected Alternative

The ambient air quality usually has effects on the public health and the biological life that includes domestic animals, fauna and flora as well as field crops.

6.4.1 Health Impacts

No Impact

The residential areas are to the east and north-east of the site (project residential areas and Masaken Abu Zaabal). Other residential area (Arab Gehena and El-Sawalha) is found at the north about 2 km from the site.

a. *Particulate Matter (PM)*

No Impact

Law 4/1994 specifies the maximum allowable concentration of PM10 in the ambient air as 70 $\mu g/m^3$ for an exposure period of 24h. Exposure to higher concentrations leads to harmful effects on breathing and respiratory systems, since they settle upon the walls of the trachea, bronchi and bronchioles. The elderly, children, and people with chronic lung disease, influenza, or asthma, are especially sensitive to the effects of particulate matter.

When the wind direction is west, the project residential area and Masaken Abu Zaabal will be subjected to very low concentrations of dust (0.18 of the allowable limit). For south wind direction, dust concentrations reaching the project residential area is 0.05 of the allowable limit. The residential area is also subjected to dust emissions from the Fertilizer Company, south-east of the site, in case of south wind direction, which still causes no problems if the area is subjected to those emissions at the same time even if the dust concentration is doubled (0.1 of the allowable limit).

b. Sulfur Dioxide

No Impact

When the wind direction is west, residential areas (project residential areas and Masaken Abu Zaabal) will be subjected to sulfur dioxide concentrations of about 0.2 of the allowable limit. In case the wind direction is south, the concentration reaching the project's residential areas is about 0.1 of the allowable limit.

It should be noted that when wind is calm, it would be risky to allow the foundries to operate causing higher ambient concentrations of sulfur dioxide. Exposure to high concentrations (above the allowable limit) causes irritation of the respiratory system, alterations in pulmonary defenses, and aggravation of existing cardiovascular disease. Children, the elderly and people with asthma, cardiovascular disease or chronic lung disease (such as bronchitis or emphysema) are most susceptible to adverse health effects associated with exposure to sulfur dioxide.

The sulfur dioxide ambient concentrations could be doubled in cases of:

- Using solar of higher sulfur content (> 0.5%), which is possible. In this case, the average sulfur content used in the model will increase to 1.5%

- Wet scrubbers are not operated all the time or their average efficiencies decrease to 60% in cases some scrubbers are not operated or need maintenance.

In both cases, the concentration of sulfur dioxide may be doubled yet they would still be below the allowable limit reaching a maximum of 0.4 the allowable limit.

Sulfur dioxide concentrations may be doubled in case all foundries melt charges at the same time in one day, which is an unlikely event, yet, the concentrations will only reach 0.6 the allowable limit.

The above concentrations would be substantially reduced in case natural gas (zero sulfur content) is used.

c. Lead

No Impact

No adverse health effects are expected in Abu Zaabal since the location of lead smelters is far away from the residential areas in the east (project residential area and Masaken Abu Zaabal) and in the north (Arab Gehena and ElSawalha about 2 km away from the industrial site). Moreover, the area close to the smelters is uninhabited.

According to WHO standards, the maximum allowable concentration of lead (for an exposure period of 1 year) is 1$\mu g/m^3$ which is the same as the maximum allowable ambient concentration in law 4/1994. Exposure to higher concentrations of lead has adverse health effects such as muscle weakness, localized paralysis, progressive mental deterioration, decreased intelligence, loss of motor skills and speech, aggressive behavior disorders and severe learning impairment. These effects usually result from intensive exposure, while other effects such as anorexia, muscle discomfort, malaise, headache, constipation, and persistent metallic taste is a common manifestation of a very slowly and insidiously developing intoxication. Exposure to lead is also linked to decreased fertility in men. Lead is a probable carcinogen, based on sufficient animal evidence and inadequate human evidence. Populations at increased risk of toxicity from exposure to lead include developing fetuses and young children, individuals with decreased kidney function, and children with sickle-cell anemia.

Moreover, the maximum deposition of lead calculated by the model is 50$\mu g/m^2$.day which is much less than the maximum allowable limit specified by WHO (250 $\mu g/m^2$.day).

Although not threatened by ambient lead concentrations, the area of radius 250-750 m around the lead smelters should be restricted to land use and development to avoid informal settlement that is usually associated with newly established industrial areas. The area adjacent to the smelters from the north could be used as a buffer zone, to minimize lead effects on adjacent foundries, by reducing the number of foundries or decreasing the streets between foundries. This is possible yet it means violating one of the principles agreed upon with the client concerning having 2 access streets for each foundry. This principle has indeed left insufficient land for buffer zones. Another option would be to move the lead smelters to the south, yet this decision is not within the scope of this report.

6.4.2 Impacts on Biological Life

One. Impacts on Flora (wild plants)

No Impact

The wild vegetation around the relocation area is typical to sub-Sahara vegetation. Most plants such as Tamarix, Alhagi and Imperata will tolerate sulfur dioxide and other gases effects, while other species will be slightly affected since these species of plants are tolerant to extreme environmental conditions.

Wild plant species, present in the area, such as Typha and Tamarix are tolerant to lead pollution. They also reduce the concentration of lead in the atmosphere by absorbing a considerable amount of it. Around the relocation area, there are no rare or sensitive species of plants.

b. Impacts on Field Crops, Soil Fertility and Soil Microorganisms

No Impact

There are strong relationship between the plant growth and microbial activities in soil or water because microorganisms are responsible for all the mineralization, synthesis, decomposition and conversion processes in the soil.

Sulfur Dioxide

No Impact

The nearest agricultural land is 2 Km. away north-east of the site. This area and its associated microorganisms, is not affected by sulfur dioxide since the effect of sulfur concentrations only reaches 1 Km from the site when the wind direction is south, where the concentrations reaching this area is 0.05 of the allowable limit.

Moreover, harmful effects of sulfur dioxide on agricultural land starts at a concentration of 1000 $\mu g/m^3$ which is about 10 times the maximum allowable concentration for sulfur dioxide. Prolonged exposure of most plants to this level of concentration causes yellowing and blotching of leaves, general weakness as well as a decrease in the rate of photosynthesis. Sulfur dioxide attacks the sensitive cells of plants, and enters the soil in the form of acid mist. It is not likely to reach such high concentration even in cases of noncompliance because the modelling results are 0.005 of this harmful concentration.

Dust

No Impact

Dust deposition does not affect the agricultural land since they are at a sufficient distance to be affected by deposited dust particles.

Lead

No Impact

Pollution from lead smelters does not threaten any agricultural land in the area since the smelters are located at a far distance from the nearest agricultural land which is not affected by lead dust nor reached by its deposition as shown in figures (6.24, 6.25).

c. Impacts on Fauna

No Impact

The number of wild animals in and around the site is not high. The impact of sulfur dioxide and lead emissions on fauna will be limited since most of them are wild dogs, rats and insects and such species usually tolerate these forms of pollution.

e. Impacts on Domestic Animals

No Impact

A number of livestock and poultry farms are located 4 km north and north east of the industrial site, producing a large number of eggs and cattle.

Sulfur Dioxide

According to the modelling results, it is clear that such farms will not be affected by sulfur dioxide concentrations since a concentration of 0.05 of the allowable limit only reaches 1km from the site thus the farms will be not be reached by sulfur dioxide concentrations.

At high concentrations, which are unlikely to be reached, sulfur dioxide stimulates broncho-constriction and mucus secretion in a number of organisms including livestock and poultry. It dissolves in lung fluids as sulfite or bisulfate and is then distributed to the different organs of the body. Harmful concentrations are those above 150 $\mu g/m^3$ which is 100 times the concentrations reaching an area only 1 km from the site.

Lead

Lead smelters are at a large distance (greater than 4 km away) from the farms and are thus not expected to affect the farms by lead concentrations or deposition.

6.5 Summary of Project Impacts

Project impacts during construction and operation phases are summarized in the matrix shown in table (6.10)

Table (6.10) Matrix Indicating Impacts of Project Activities on Environmental Elements

	Environment							Social- Economical						
	Natural & Biological			Quality										
	Landscape	Flora& Crops	Fauna & Animals	Water	Air	Land	Noise	Occupational Health	Public Health	Services	Direct Employment	IndirectEmployment	Lifestyle Impacts	Industrial Development
Relocation Phase:														
Moving industries from Shoubra El kheima*	+	+	+	0	+	0	+	+	+	0	-	-	0	0
Construction Phase:														
Earth Works	+	-	-	0	0/-	0	-	0	0	0	+	0	0/-	0
Infrastructure Works	0	-	-	0	0/-	0	-	0	0	0	+	0	0/-	0
Laying of asphalt concrete roads	+	-	-	0	0/-	0	-	0	0	0	+	0	0/-	0
Building of Services(ww plant,transfer station..)	0	0	0	0	0/-	0	-	0	0	0	+	0	0/-	0
Operation Phase:														
Foundry Operation**	-	0	0	0	-	0	-	+	0	+/-	+	+	-	+
Traffic on Roads	0	0	0	0	-	0	-	0	0	+	0	+	0	0
Residential Areas	0	0	0	0	0	0	0	0	0	+	0	+	0	0
Green buffers and green areas	+	+	+	0	+	+	+	0	+	+	0	0	0	0

- Negative Impact
0/- Minor Negative Impact
0 No Impact
+ Positive Impact

* Impact on Shoubra El Kheima
** Impact due to foundry operations plus its services (general stores, solid waste transfer station and waste water treatment plant)

Chapter 7

Urban Master Plan

Based on the selected alternative (chapter 6), the urban plan is finalized. The land budget and distribution is specified. Moreover, the future potential need for expanding the industrial area is discussed.

- All industry requests to relocate could be met. There are 32 additional plots for allocation mostly of the 200 and 500 m^2 types.

- The residential district is totally separated from the industrial zone both in terms of location and access. The district could house a total of 4500 to 5500 inhabitants.

- Services are distributed into main and sub-centers for both industrial and residential area to accommodate all demands for each zone.

- The distribution of different land uses meets accepted norms except for the percentage of roads in the industrial area (36%) which is higher than usual because of the demand for two access streets for each industrial plot (regulated by the law as one except for corner plots). This decreases the percentage of commercial land in the industrial area to 7% (industrial plots and services 43% and 14% respectively).

- The direct traffic created by the industrial estate could easily be accommodated in the existing external road network. A cross section design of the internal network is proposed.

- Executive drawings are included in appendix (L). These drawings are also the basis for building design.

The master plan integrates the results of all the sectoral studies into one comprehensive concept. The task of the plan is to propose the physical planning for the entire development, showing the spatial distribution and location of all functions and facilities.

The main objective of this development is to relieve Cairo and its vicinity from uncontrolled polluting industries and relocate them to an industrial estate planned to be a self-sustained industrial settlement that seeks to enhance the economic base of the region.

7.1 Spatial Distribution

The industrial settlement, being developed near the "agricultural" artery connecting Cairo and Ismailia cities and along "Sekkat El-Madaress" road. The industrial site is accessed by five roads: two serving the residence to the north, and three serving the industrial plots to the north and south as well as further extensions to the site.

The railway line intrudes the site and bisects it into eastern and western regions. Eastern region houses the residential area and needed services while the western region is dedicated to the industries and relevant services. The services edge the industrial development, on the "Sekkat El-Madaress" road, in an effort to serve the vicinity population as well as the residences and industrial development on the site.

7.2 Industrial Development

7.2.1 Structure

Environmental conditions necessitate the following location distribution:

- Large foundries, using induction furnaces, are located abutting the railway acting as a buffer between industrial workshops (using crucible furnaces) and the residential area.

- Industrial workshops (using fossil fuel) are subdivided between the north and south to reduce the concentration of emissions. They are separated by small industries, the industrial services and estate management.

7.2.2 Internal Organization and Land Budget

The pattern is based on a variation of modular block depths 20, 25, 35, 60 & 100 meters which relate to the modular order for the construction of industrial buildings. Road network is developed as a grid with "T" intersections providing comfortable and easy access for truck traffic. Between these intersections, the land can be parceled according to individual industrialists' demands. Sizes of plots are determined by the modular size of the block and the parceling dimension which guarantees maximum flexibility and shape. Adjoining sites could be reserved for a predetermined period as extension sites.

Off the total land area (607521 m^2), 30874 m^2 (5.25%) is rendered unusable land to buffer railway track and 576647 m^2 (94.75%) usable. The area of land suitable for development is budgeted as shown in table (7.1). *Appendix (J) shows the land budget of the area and appendix (K) gives the land use.*

Table (7.1) Total Land Budget

Land Use	Area in m^2	Percentage
Industrial Area	435464	75.5%
Residential Area	124956	21.7%
Central Services	16227	2.8%
Total	576647	100.00

The industrial sector is broken down to net areas as shown in table (7.2)

Table (7.2) Net Areas of different Industrial Sectors

Type	Area	Percentage
Plots	187101 m^2	43.0%
Roads	157354 m^2	36.1%
Services	43007 m^2	13.8%
Green Areas	48002 m^2	7.1%
Total	435464 m^2	100.00

The break down of net industrial development according to size reveals the following number of facilities, total areas and percentage by type as shown in table (7.3).

Table (7.3) Number of Planned Plots

Type	Number	Required No	Area in m^2	Percentage
Workshops (200)	31	12	6213	3.3%
Workshops (500)	30	20	15000	8.0%
Small (1000)	20	20	19600	10.5%
Medium (2000)	20	20	41873	22.4%
Medium (5000)	14	12	70000	37.4%
Large (10000 up)	3	3	34415	18.4%
Total	119	87*	187101	

* Originally 90, three lead smelters were already allocated land adjacent to the development site.

It is clear that the number of planned plots exceeds the number of relocated foundries. Extra plots should not be used to relocate more foundries or other polluting industries. They may be occupied by industries that use the castings as raw materials or other activities that are vital to foundries operation. Incompatible industries should not be allowed into the site. The list of incompatible industries includes food industries, precision/clean environment industries, pharmaceutical industries, finishing or painting industries, etc.

7.2.3 Industry Built Area

The specification of setbacks and built area for industrial workshops and plots should address a variety of issues including plot dimensions, building/plot index, floor area ratio, and relative land pricing. The primary goal for setting relative criteria is to compensate the industrial restrictions placed on larger plots while in the same time relatively decreasing the cost/meter build as the plot size increases.

Table (7.4) shows the various plots and recommended settings for different parameters.

Table (7.4) Recommended Settings for Setback Parameters

Type	Plot Breadth	Plot Length	Plot Area	Setback	Sides with Setback	B-with Setback	L- with Setback	A- with setback	Index	Index Area	FAR	Tot Built Area
200	10	20	200	0	None	10	20	200	1	200	1	200
500	20	25	500	0	None	20	25	500	1	500	1	500
1000	28	35	980	6	Front	28	29	812	1	980	0.9	882
2000	35	60	2100	6	FSSB	23	48	1104	0.5	1050	0.8	1680
5000	50	100	5000	6	FSSB	38	88	3344	0.55	2750	0.75	3750
10000&up	100	100	10000	6	FSSB	88	88	7744	0.6	6000	0.7	7000

The table shows that the setbacks act as the restrictive building tool (setback area lower than index area) for workshops, while plot index acts as the restrictive criterion for industrial plots. The Floor Area Ratio (FAR) is employed to give advantage to larger plots requiring larger investments.

The relative price indexes should be carefully considered in order to balance investment in larger plots with restrictions concerning technological process. The cost per meter built should relatively decrease as workshops and plots increase in size.

7.3 The Residential District

The residential district is composed of one neighborhood extending linearly from north to south of the eastern region. It is composed of medium density blocks 4 stories in height. The district is flanked to the east (overlooking the "El-Madaress" road) by the main service center housing religious, financial, postal, communication and commercial services. A sub-center is located at the mid-northern part serving the northern residences with essential daily and weekly commercial demands.

Small parks located near the service centers provide the residential population with recreation and sports facilities.

The residential district is accessed through perimeter collector roads which avoid through traffic. The system guarantees full accessibility, delivery to service facility, and minimum disturbance and danger to inhabitants.

The residential sector is broken down to net areas as shown in table (7.5).

Table (7.5) Net Areas of different Residential Sectors

Type	Area	Percentage
Plots	52200 m^2	41.8%
Roads	38491 m^2	30.8%
Services	21166 m^2	16.9%
Green Areas	13099 m^2	10.5%
Total	124956 m^2	100.00

Building coverage (index) is set to 0.5. The number of stories is 4 stories plots are set to 600 m^2 and floor area ratio (FAR) is 2. Building floor area is 300 m^2 and area per person of floor area is 23 m^2/person rendering a total population of 5568 inhabitants.

The flexibility of accommodating different housing demands is not offered through different plot sizes but rather through the flexible design of building. The

300 m^2 floor area can be redesigned to accommodate the diversity of space demands as shown in table (7.6).

Table (7.6) Space Demands for Buildings

No.	Service	No. of Apartments	Net/Apartment	Total Floor Area
1.	60	4	60	300
2.	60	3	80	300
3.	60	2	120	300
4.	60	1	180	
		1	60	300
5.	60	1	240	300

Setbacks are set at 2.5 meters to the side and back; and 7.5 meters in front. The large front setback provides personal play space and enhances the streetscape.

7.4 Services Centers

Service areas are provided for both industrial and residential areas along the eastern edge.

7.4.1 Services for Residential Area

To the north, the residential area is serviced by the religious, commercial, educational and recreational services as well as public offices providing financial, postal and communication services. Table (7.7) gives the area of different services in the residential area.

Table (7.7) Residential Services

Type	Area	Percentage
Bank, Post, Telephone	1097 m^2	5.1%
Commercial	2376 m^2	11.2%
Religious	2391 m^2	11.3%
Youth Center	2917 m^2	13.8%
Pedestrian	1683 m^2	8.0%
Sub-center	864 m^2	4.1%
Education	9837 m^2	46.5%
Total	21165 m^2	100%

7.4.2 Services for Industrial Area

The industrial area is served with a transfer station, storage area, fuel station, extended parking and industrial wastewater treatment plant. These facilities start at the eastern boarder of the western region and extend inward and to the south.

Table (7.8) Industrial Services

Type	Area in m^2	Percentage
Transfer Station	8131	18.8%
Truck Parking	7425	17.3%
Storage	13663	31.7%
Utilities*	5040	11.6%
Commercial Sub-center	2160	5.0%
Fuel station	6588	16.6%
Total	43007	100%

* Utilities include wastewater treatment plant and electricity transformers

The industrial services are followed by central services including transportation services, at the southern tip of the eastern region, and environmental and management facilities including a police station, fire brigade, health center, environmental agency and city management; all located in the central eastern part of the western region.

Table (7.9) Central Services

Type	Area	Percentage
Police	1511 m^2	9.3%
Fire Brigade	1828 m^2	11.3%
Health Center	1106 m^2	6.8%
Environment Protection	1106 m^2	6.8%
Estate Management	4338 m^2	26.7%
Transportation Station	6338 m^2	39.0%
Total	16227 m^2	100%

Several small service areas are located in the residential and industrial areas to serve distant populations. The distribution of services is shown in table(7.10)

Table (7.10) Distribution of Services

Type	Area	Percentage
Central Services	16227	16.7%
Industrial Services	43007	61.6%
Residential Services	21166	21.7%
Total	123938	100%

7.4.3 Services Built Area

A 6m setback should be considered for service plots. The Floor Area Ratio should be tentatively set at 1 pending particular programmatic requirements and detailed architectural and urban studies.

7.5 Green And Recreational Areas

Three distinct categories of vegetation are found in the industrial site. First, there are the planned parks both in the residential and industrial areas. Second, the streetscape with its heavily planted tall trees represents the major visual impact of greenery in the city. Third, the "left-over" portions of lands along the edge of the city shall be taken advantage to provide playgrounds and recreation.

Table (7.11) Green and Recreation Areas

Type	Area	Percentage
Industrial Greens	48002	79%
Residential Greens	13099	21%
Total	61101	100%

7.6 Extensions

Extension of industrial facilities is dealt with in general by reserving adjacent plots for a predefined time (5 years). As far as future demands can be seen, the road pattern is planned for the possibility of regional extension to integrate new development south and west. The main roads extend to integrate the new extension to the west as shown in fig(7.1).

7.7 Infrastructure Requirements

7.7.1 Industrial Area

Infrastructure requirements, for the industrial area, were calculated based on the technologies applied in the foundries and are shown in table (7.12).

Table (7.12) Infrastructure Requirements for Industrial Area

Item	Daily Consumption
Water	9500 m^3/day
Electricity	1810000 kWh/day
Wastewater	5100* m^3/day

* Assuming cooling water is recycled in case of induction furnaces only

In case the industrial estate is provided with natural gas, the above calculations should be reviewed taking into consideration the number of large foundries that might prefer to use cupola furnaces with natural gas instead of induction furnaces.

It is recommended to provide the industrial site with natural gas. It is hard to predict the reduction in electricity consumption if natural gas is used. Close consultation with foundries operators would be necessary to investigate the possibility of switching to natural gas instead of using coke and liquid fuel. Large foundries might consider using natural gas instead of induction furnaces, yet the decision depends on several issues such as the quality of castings, that is higher in case of induction furnaces.

7.7.2 Residential Area

Infrastructure requirements for the residential are shown in table (7.13).

Table (7.13) Infrastructure Requirements for Residential Area

Item	Daily Consumption
Water	1200* m^3/day
Electricity	70558** kWh/day
Wastewater	960 m^3/day

* Based on a total of number of inhabitants equals 5568
** Based on 1392 apartments

7.8 Transportation and Roads

7.8.1 Access to Site

The designated area is located at the North Eastern part of Qalubia Governorate 35 km away from Cairo. At the regional level, it is accessed by Ismailia Agriculture Highway, which is a dual 2-lane carriageway with 7.5 m traffic lanes in each direction with a median of a variable width ranging from 0.5 to 4 m. The highway pavement, in most of its segments, is in good condition, yet it requires lighting and other traffic control measures to improve the traffic safety and reduce the hazardous driving conditions specially during night time.

At the local level, the area is located to the west of Msaken Abu Zaabal area, and can be reached by two roads: Road No. 400 and El Madares street, as shown in fig (7.2).

- Road No. 400 is a dual 2-lane carriageway with a total right-of-way of 26.0 m comprising: 10.0 m traffic lanes in each direction with a 2.0 m median and 2.0 m sidewalks. The road pavement condition is considered average, while the median and sidewalks are mastic asphalt but requires maintenance. There are lighting poles mounted on the median, but they are operative. The average daily traffic on this road is about 4300 vehicles/day, mostly destined to Al Arab and Shebin Al Kanater areas, with the following composition: 25% private cars and taxis, 41.7% pick-up vehicles (for people and goods transport), and 33.3% light and heavy trucks. The road operates at a very good level of service, despite the high percentage of trucks.

- Al Madares street is a local road branching from the Roundabout facing El Sekka El Hadeed Club. The road is in a poor condition with bad pavement condition, no sidewalks (just shoulders with no curbs to segregate between pedestrians and vehicles), no lighting (despite the presence of lighting poles on the eastern side of the street). The area is mostly undeveloped and very little traffic is observed. The existing street carriageway is a single 2-lane road with 7.0 traffic lanes in each direction.

7.8.2 Transportation Planning

A transportation study was conducted to estimate the expected future traffic generated from the new development and assess the proposed road network carrying capacity. Table (7.14) summarizes the land use parameters relevant to the transportation study.

Table (7.14) Total Transported Material*

Land Use	Raw Materials (ton/day)	Product (ton/day)	Total (ton/day)
Cast Iron	1370	1300	2670
Aluminium & Copper	170	130	300
Lead	200	145	345
Overall	1740	1575	3315

* Calculated based on applied technologies and production capacities

The raw materials will be in the inbound direction (i.e. to the site), and the final products will be in the outbound direction (i.e. from the site to the market). Given an average truck load of 6.0 tons, the amount of daily trucks will be as follows:

- Inbound: 290 truck/day
- Outbound: 263 truck/day

Using a peak hour factor of 10%, the expected peak hour truck traffic would range from 27 to 29 truck/hour. Given the present traffic composition in the study area where trucks represent about 33% of the traffic, then the overall peak hour traffic flow would be some 100 vehicle/hour. Such a low traffic volume can be accommodated within the proposed roads cross section at a good level of service.

7.8.3 Design Criteria for the Area Internal Roads

The objective of such an industrial area is to relocate foundries and to providing adjacent residence area for its workers to minimize vehicular transportation from residence to work. Therefore, within the community, transportation of workers would basically be by foot. The planning design would ensure a maximum walking distance ranging from 1.0 to 1.5 km (i.e. equivalent to a 15-minute trip).

Currently, a cargo railway line penetrates the site in the North-South direction, connecting the Fertilizers Company to the National Railway Network. The current alignment has been maintained while providing a 20 m right-of-way along its route inside the site.

Given the residential/industrial mixture planned in the site, four types of roads are proposed as follows:

a. Road Type 1

It is a 28 m collector road connecting between the site with the surrounding roads. It collects traffic from both the residential and industrial areas and feeds into Al Madares street. The overall length of this road type is 1.9 km.

b. Road Type 2

It is a 20 m local road providing access to the plots in the industrial area. Movements on this type will be mainly for the transportation of inputs and outputs (raw materials, final products and wastes). The overall length of this road type is 5.73 km.

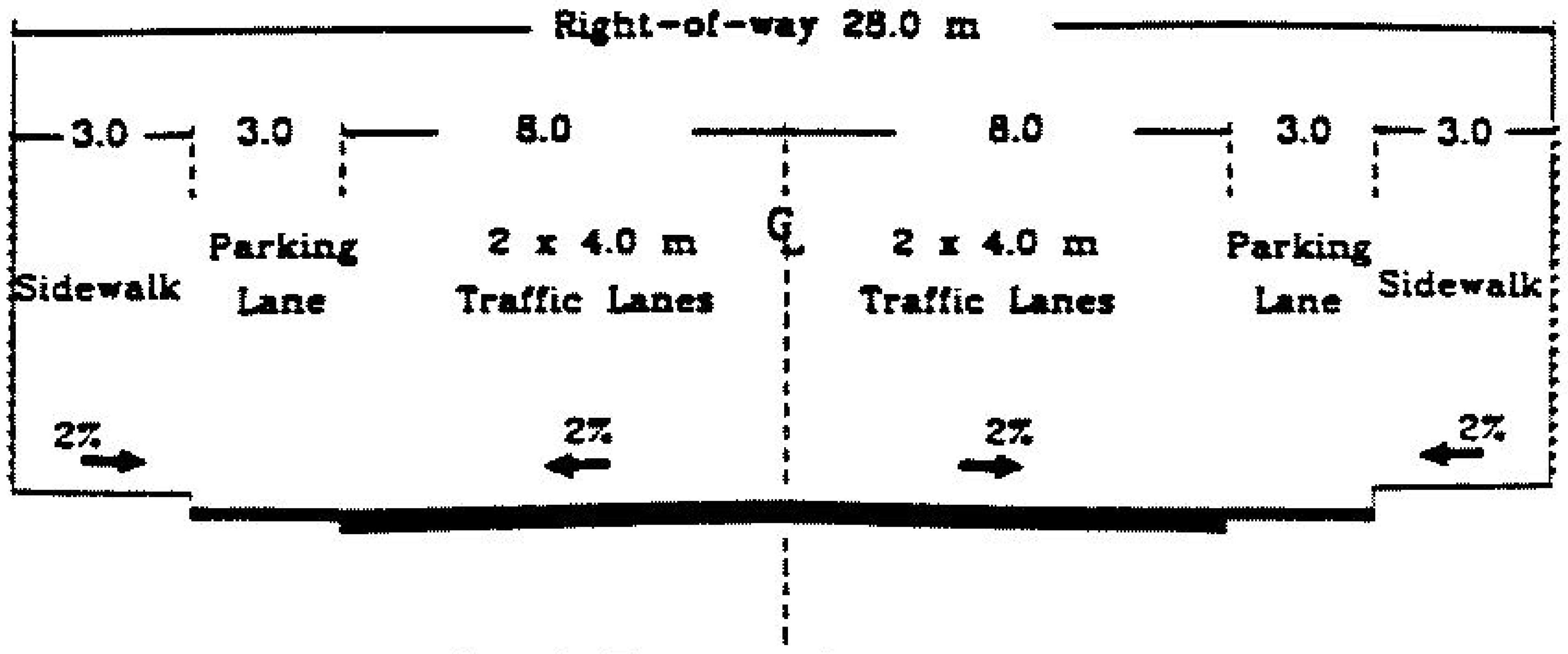
c. Road Type 3

It is a 16 m local road providing access to plots in the residential area. The overall length of this road type is 2.63 km.

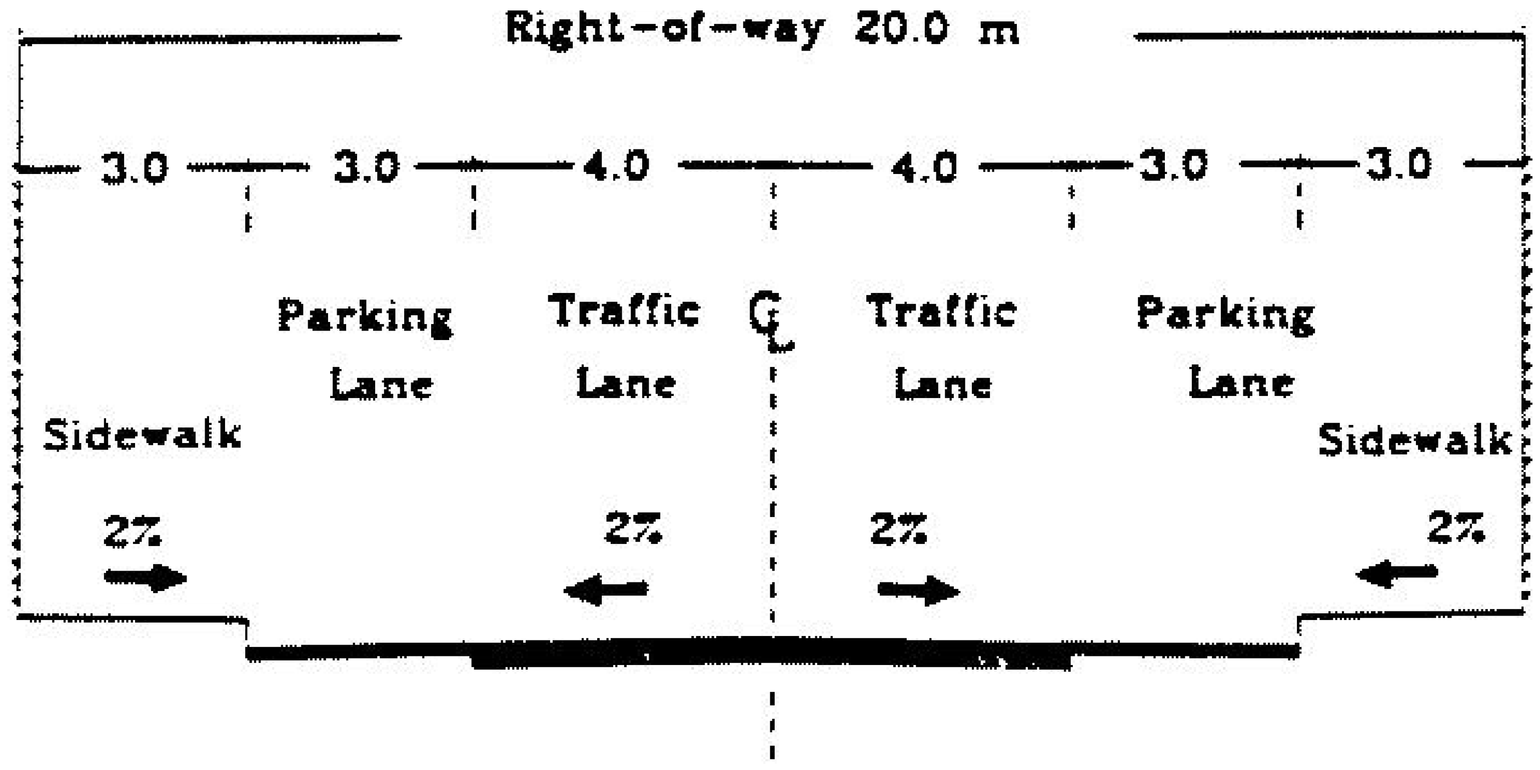
d- Road Type 4

A 8 m pedestrian footpath can be implemented inside the residential area (wherever possible) to facilitate pedestrian movement among the plots given the expected high percentage of walking trips.

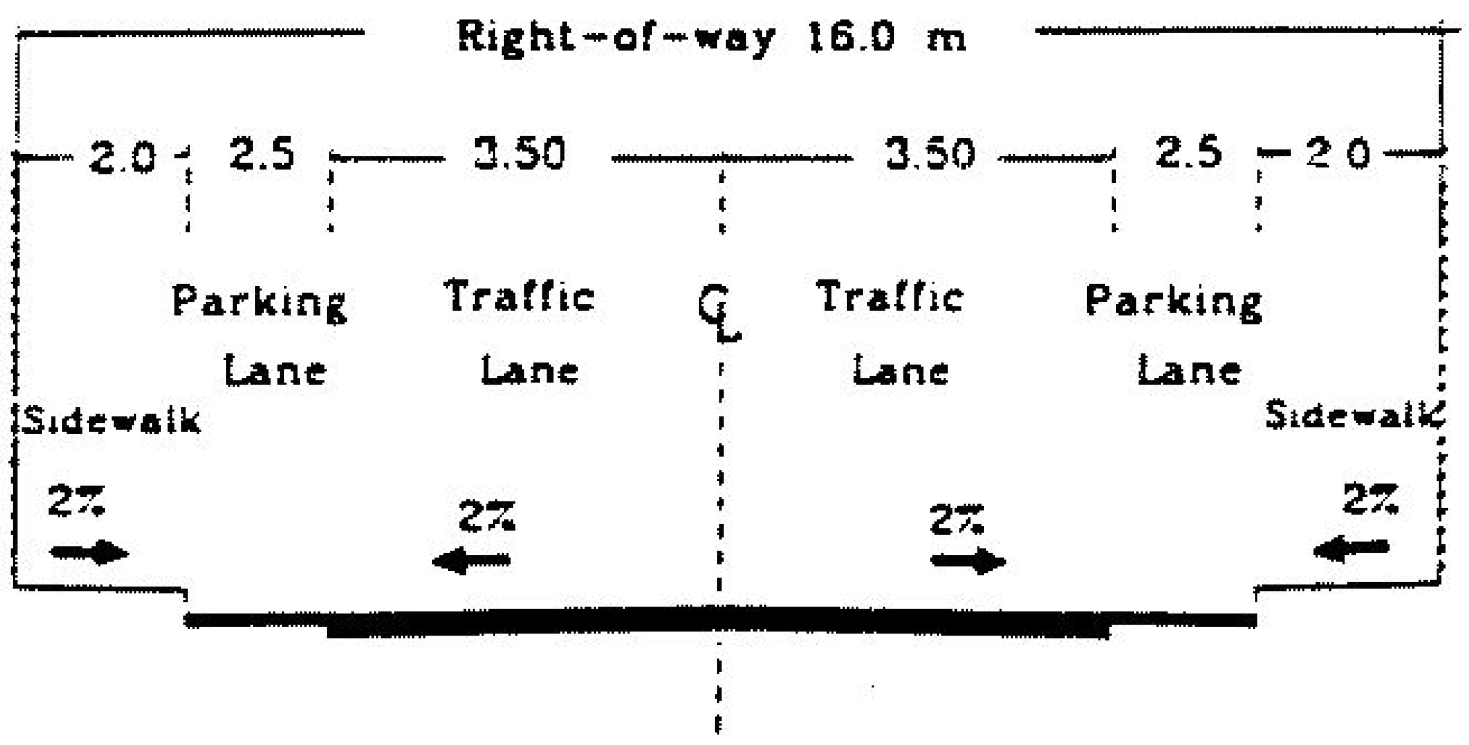
Figure (7.3) illustrates the proposed roads cross sections.



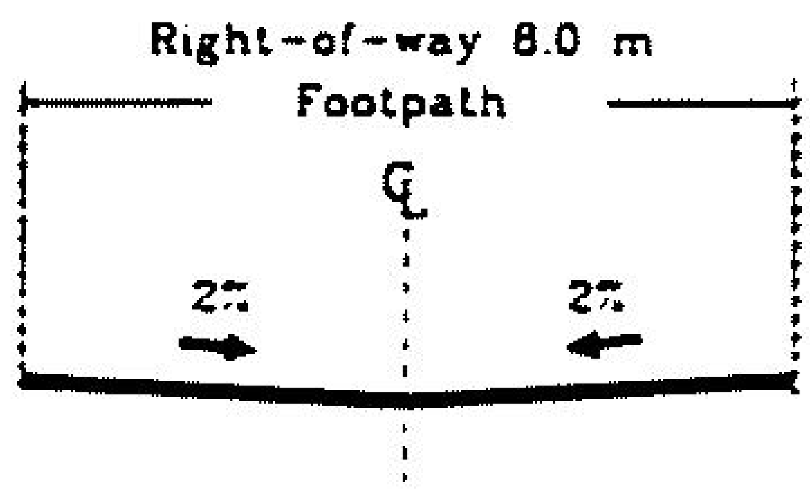
Road Type 1 Cross-Section



Road Type 2 Cross-Section



Road Type 3 Cross-Section



Road Type 4 Cross-Section

Fig (7.3) Proposed Road Cross Section

Chapter 8
Conclusion and Recommendations

Based on the analysis of the previous chapters, the project achieves an optimal balance of high-density industrial development while controlling negative environmental impacts.

As an additional safety factor, especially concerning air pollution, it is recommended to restrict the total production capacity of the estate to a factor of the listed required capacity (chapter 1), which is already 2-3 times higher than the current production of the relocated foundries. Eventually, the ceiling would be incrementally relaxed based on positive results of environmental monitoring in the area.

This document is submitted to EAA for approval based on a commitment from the Governorate that the industrial scheme will be implemented as planned. In addition to its own responsibilities, the Governorate would also insure that all parties involved assume their own. These includes:

- Construction companies;
- Utility companies;
- Industrial operators
- Estate management; and
- Industrial service operators.

The chapter enumerates the responsibilities for each party.

The industrial estate in Abu Zaabal in which metal foundries from Shubra El Kheima will be relocated is planned to minimize negative effects on the environment and the neighboring receptors. The environmental effects of this development are shown (in chapter 4 to 7) to be within the legally prescribed limits.

In order to reach this optimal configuration of high density industrial development with minimal environmental effects, a number of mitigation measures were recommended throughout the report. The govrnorate of Qalubiya is committed to implement the industrial development scheme as planned. It will therefore insure that all involved parties assume their responsibilities in implementing these mitigation measures and providing the necessary inputs to allow for its adequate implementation.

8.1 Responsibilities of the Governorate

The project promoter, the Governorate of Qalubiya, is naturally the party ultimately responsible for the environmental performance of the industrial estate from its inception and continuously throughout its operating life- time.

8.1.1 Concerning Necessary Inputs to Implementation

- Insure that utilities (see chapter 7) with required capacities are available to the site.
- Adequate upgrading and control of the dumpsite adjacent to the industrial estate.
- Identify the legal and financial arrangements to establish and sustainably operate the recommended central services.

8.1.2 Concerning Controlling Impacts During Construction

- Reflect the mitigation measures described in chapter 4 in the contracts of companies responsible for major and infrastructure works of the site.

8.1.3 Concerning Operation and Management of the Industrial estate

- Insure that industrial operators are aware and bound, through contractual agreements, to their responsibilities (section 8.2)
- Establish an industrial estate management reporting to the governorate to manage the site during construction, land allocation and later during operation (section 8.3). The estate management would have a specialized environmental unit responsible for maintaining and monitoring the environmental quality and effects of the development (section 8.4).

8.1.4 Concerning Protection of Surrounding Land

- Prevent the creation of informal settlements.
- Create a buffer in the open areas surrounding lead smelters south of the estate.

8.2 Responsibilities of Industrial Operators

All industrial operations should comply with work environment and emissions standards specified in law 4/94 except for SO_2 emissions where the limits set for the industrial estate (200 mg/m^3) are lower than those specified in the law. Moreover, the industrial operators will abide by the following rules and restrictions included in the contractual agreement to operate on the Abu Zaabal industrial estate. Individual EIA's would also be submitted and approved for each plant in conjunction with its licensing procedures.

8.2.1 Technological Standards

- Iron foundries of area greater than 1000 m^2 should use induction furnaces for melting. This standard will be revised when natural gas is made available to the industrial estate (see chapter 7).
- Wet scrubbers of design efficiencies greater than 85% are applied to all stacks of furnaces using fossil fuel.
- The height of the stacks are 30 m for furnace and handle heating stacks and 25 m for shake out and sand station stacks
- Use of fuel oil (mazot) is forbidden and the sulfur content of solar should not exceed 1%.

8.2.2 Operation Time

- Fossil-fueled furnaces are only operated for 10 hours a day during the period from 7 a.m. to sunset
- Operation is forbidden after 10 p.m.
- Operation is discontinued in calm wind conditions.

8.2.3 Waste Management

- Industrial wastewater is discharged to the network leading to the central treatment plant. Oil and grease, as well as cyanides should be removed before discharge. Settlable solids are also reduced before discharge.
- Solid waste generated should be delivered to the estate transfer station. No waste is allowed to be transported individually outside the estate.
- The operators will be charged for the services provided by the estate for waste management according to a transparent formula.

8.2.4 Housekeeping and Material Management

Examples are:

- Paving and water spraying open areas of the industrial units to minimize ground level dust pollution.
- Use foundry sand only.
- Proper storage of material on-site.
- Briquetting scrap charged to furnaces to minimize fugitive emissions.

- Cleaning scrap to remove any non-metal material, especially plastic, a major source of hazardous air pollutants.

8.2.5 Environmental Register and Monitoring Program.

Each foundry should have a self-monitoring program, the results of which are included in the environmental register.

a. Gaseous Emissions

The gaseous emissions from stacks should be in compliance with the limits of law 4/1994 (and 200 mg/m^3 for SO_2). The monitored parameters include particulates, carbon monoxide, sulfur dioxide, carbon dioxide and nitrogen oxides. Table (8.1) recommends the monitored parameters in the different foundry units together with the monitoring frequency.

Table (8.1) Monitoring of Gaseous Emissions

Location	Operation Mode	Control Device***	Pollutants	Monitoring Frequency
Melting Furnaces Cupola Induction Rotary Crucible	 Continuous Batch Batch Batch	Wet scrubber	Particulates (metal oxides, dust), fumes, CO, SO_x*,	Every 3 months
			NO_x, CO_2	annually
Pouring Stage Ladle Preheating Heat Treatment	 Continuous Batch	Wet scrubber	Particulates (metal oxides, dust), fumes, CO, SO_x,	Every 3 months
			NO_x, CO_2	annually
Molding and Core Making Core Dryers Shell Molding Gravity Molding Centrifugal Molding Lost Wax Dryers	 Batch Continuous Continuous Continuous Batch	Wet scrubber	Particulates (silica Coal dust), fumes, CO, SO_x,	Every 3 months
			NO_x, CO_2	annually
Shakeout and Fittling Unit and Sand Station Mixers Aerator Conveyors Magnetic separator Shaking-out machine Shot blast machine Grinders	 Batch Continuous Continuous Continuous Continuous Batch Continuous	Bag Filter**	Particulates (silica, metal oxides)	Every 3 months

* SO_X is not measured in case of induction furnaces

** for large foundries. Small foundries may use wet scrubbers

*** There should be continuous checks to evaluate the performance of the control devices

b. Monitoring of Working Environment

- Air monitoring of the emission sources for dust and gas emissions is necessary to protect operating personnel inside the production units. Table (8.2) gives the monitored parameters and the monitoring frequency of each.

- Periodical medical examinations should be provided for workers for biological and physical monitoring. In particular, those employees working in areas with excessive heat, noise, and high concentration of particulate materials and gaseous emissions.

Table (8.2) Monitoring of Working Environment

Location	Pollutants/Monitoring Frequency								
	CO	**SO_x**	**Particulates**	**NO_x**	**CO_2**	**Chemicals Fumes**	**Illumination**	**Heat Stress**	**Noise**	**Remarks**
Melting and Pouring	Every 3 months	*Every 3 months	Every 3 months	annually	annually	-----	Every 1 month	Every 1 month	Every 1 month	- Particulates include metal oxides and silica
Molding and Core Making	Every 3 months	**Every 3 months	Every 3 months	annually	annually	Every 3 months	Every 1 month	Every 1 month	Every 1 month	- Particulates include silica, coal dust - Chemical fumes may include organic fumes according to chemicals used
Sand Station			Every 3 months				Every 1 month	Every 1 month	Every 1 month	- Particulates include silica, coal dust, clay
Fittling Area			Every 3 months				Every 1 month	Every 1 month	Every 1 month	- Particulates include silica
Compressor						Every 3 months		Every 1 month	Every 1 month	- Chemical Fumes include oil vapors
Generator						Every 3 months		Every 1 month	Every 1 month	- Chemical Fumes include oil vapors

* not to be measured in case of induction furnace
** according to fuel used in drying furnaces (baking)

8.3 Responsibilities of the Estate Management

8.3.1 Management of Contracts

- With construction contracts.
- With industrial operators.
- With service operators and central services (if contracting out of these services is found viable).

8.3.2 Excess Land Allocation

Almost 30 land plots for workshops are available for allocation to industrial operators. These should be allocated to activities serving the metal foundry operators or using their products. No additional polluting industries should be located in the estate. Sensitive industries such as food or precision industries should not be considered.

8.4 Responsibilities of the Environmental Management Unit (EMU)

An environmental management unit (EMU) should be established in the site to maintain the environmental quality in the area. Inspectors will conduct routine inspections on the foundries and evaluate the monitoring results of each foundry. Inspection teams from Qualubia governorate EMU may assist the site unit in conducting inspection and monitoring in the area. The site EMU will be responsible for:

8.4.1 Inspection of Industries

- Review the environmental registers of the foundries
- Inspect the foundry for non-compliance
- Make sure that control measures are in place and operating efficiently
- Perform analyses to check the credibility of analyses conducted by the foundry
- Inspect the foundry wastewater collection tank
- Ensure that foundries obey the operation time restrictions
- Make sure that control measures are operated all the time

8.4.2 Inspection of Central Services

- Inspect the performance of the wastewater treatment plant

  The central wastewater treatment plant effluent should be monitored to detect any fluctuation in the pollutants concentration and ensure compliance with law 93/1962. Table (8.3) gives the monitored parameters.

Table (8.3) Monitored Wastewater Parameters

Parameter	Monitoring Frequency
PH	Daily
Total Solids	Every week
Total Suspended Solids	
Total dissolved Solids	
Settlable Solids	
BOD	
COD	
Oil and Grease	
Sulfides	Every month
Iron	
Lead	
Copper	
Nickel	
Zinc	
Chromium	
Cyanide	Every 3 months

- Raw materials are properly stored in the central stores.
- Ensure that estate regulations concerning waste collection (in transfer station) are followed.

8.4.3 Monitoring of Ambient Air

The ambient air in the site should be monitoring weekly to ensure compliance with environmental standards and guide the estate management decisions concerning the eventual increase in production capacity. The monitored pollutants include sulfur dioxide, carbon monoxide, PM10, lead and dust. (in locations of expected highest concentration according to the meteorological regime.

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